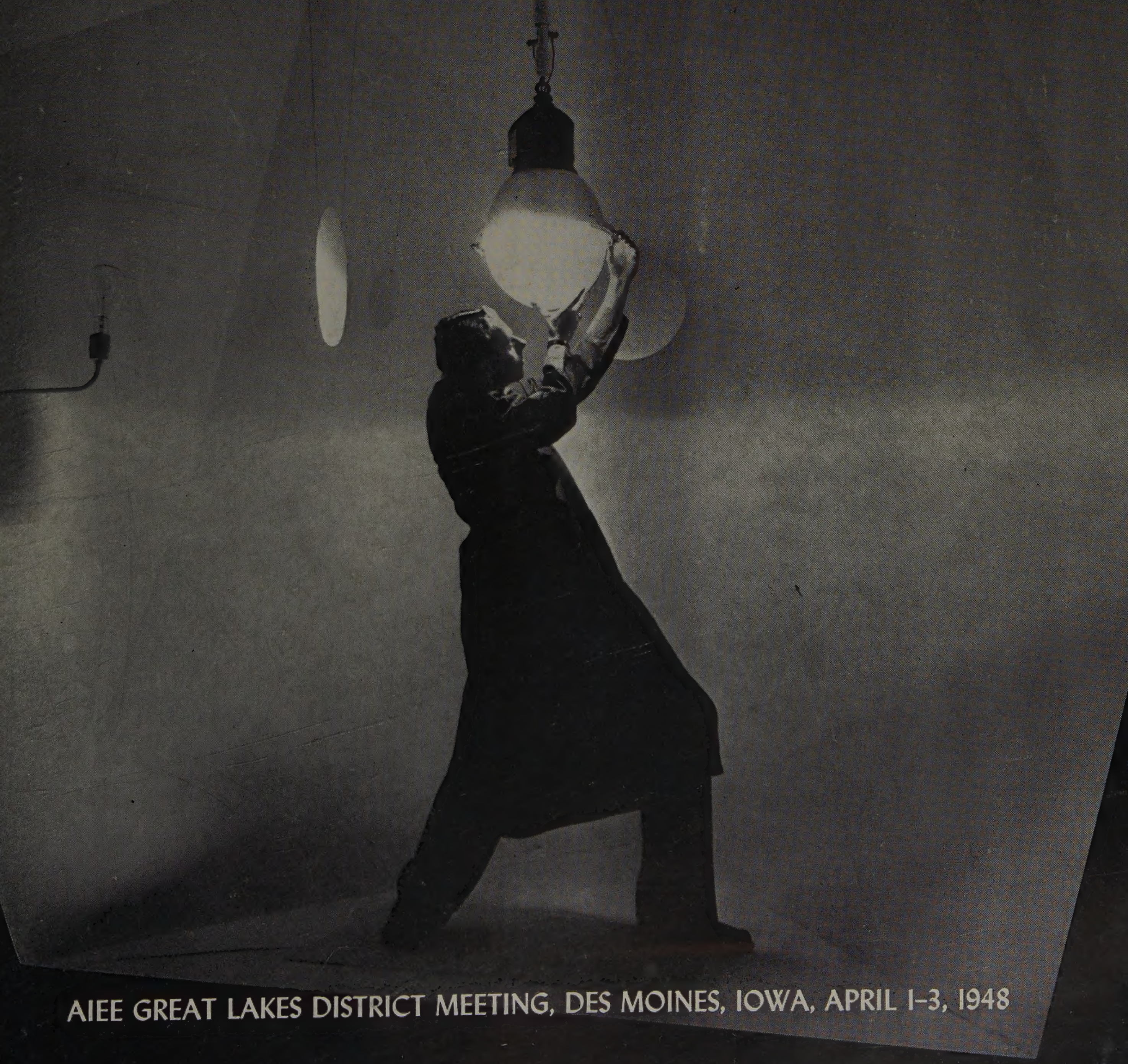
ELECTRICAL ENGINEERING

MARCH 1948



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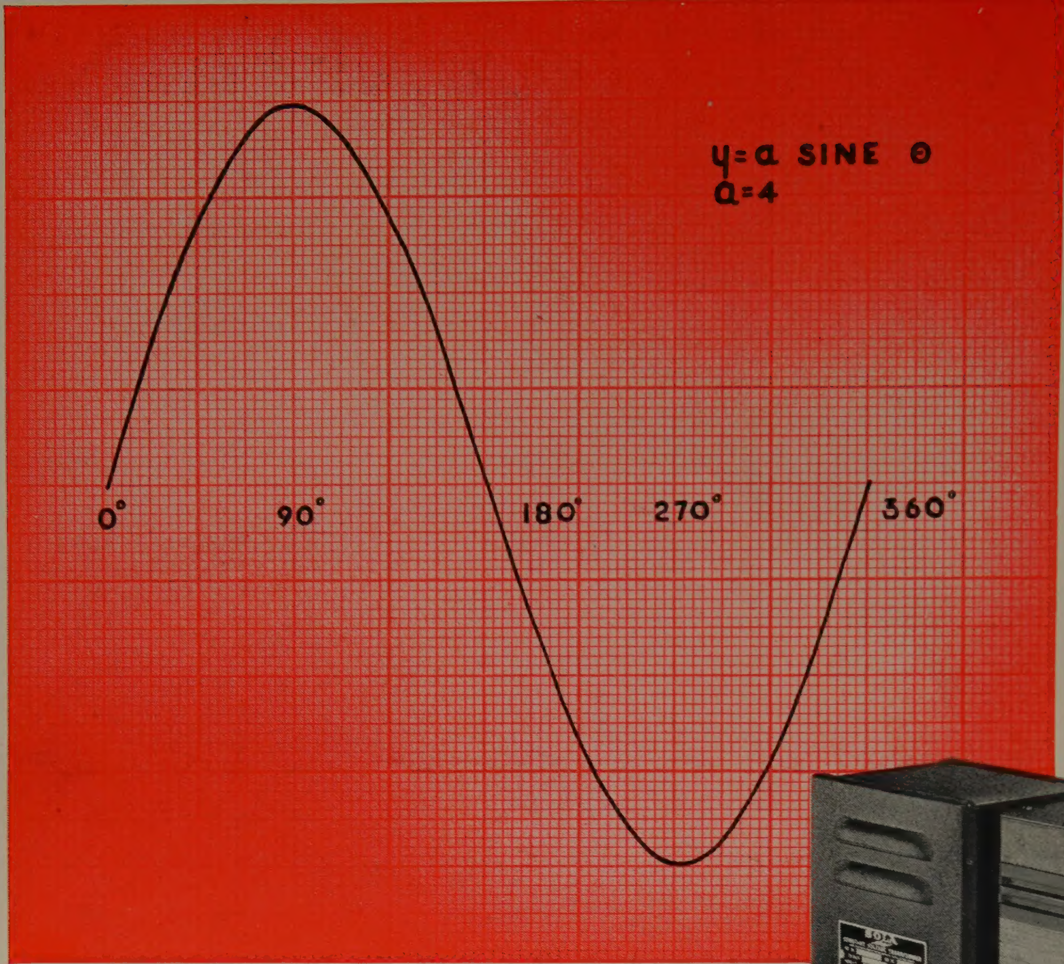

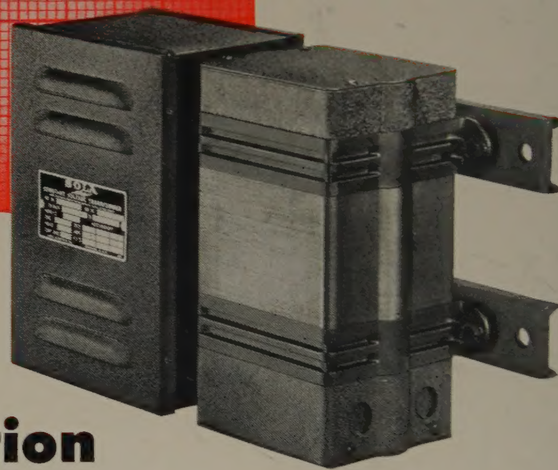

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The Cover: Known to lighting engineers as an icosahedron, this room is used to test the efficiency of new type street lighting units. The white walls provide perfect light reflection, the brightness of which is measured by a photoelectric cell located in a small window at one side of the shell-like room.

Westinghouse photo

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Mexican Holiday

A. P. KITCHEN
ASSOCIATE AIEE

"Make the 1948 summer general meeting an exciting vacation in colorful Mexico." This theme is seconded vigorously by the author who gives a first-hand account of what to expect on a holiday in Mexico.

EXCLUDING Canada as country much like the United States, Mexico, to Americans, is their most accessible foreign land. A 2-day train ride from New York or Philadelphia brings one to Laredo, Tex., the border city, where a 3-hour stop for custom's inspection is made. From that point the Diesel-powered air-conditioned train continues for 32 hours through beautiful mountainous terrain southward to the capital city. It is possible to make the train ride from eastern cities to Mexico City in a Pullman car without change in $3^1/_2$ days, or by air overnight. This part of Mexico operates on Central Standard Time.

The charm of Mexico is a composite of many things. One of these is climate. Because of the high altitude of the tablelands of central Mexico—7,350 feet at Mexico City—and because of its location in the tropic zone, it is a land of sunshine and of even temperatures through the year. The thermometer rarely goes below 60 or above 85 degrees, and the humidity is low. While summer is their rainy season, so-called, the rain is light, and it falls late in the day so that it does not seriously interfere with plans for sightseeing.

The sound of another language is in the air everywhere. Its even flow is music to the ears of the visitor from the north even if he cannot understand it. And how much more enjoyment there is for the tourist who has brushed up on his high school Spanish before going to Mexico! It gives one a real thrill to find that he can be understood by the "hombre" behind the wheel of the taxi or the "senorita" who waits on his table.

The use of a different currency, with pesos at approximately 5 to the dollar and with centavos at 100 to the peso, is like playing a new game until the novelty wears off. And there are likely to be many mistakes while learning!

Much of the charm of a Mexican trip lies in the dress of the natives. The population, predominately of Indian descent, moves about slowly, on foot or on burros, with serape over shoulder, and sombrero on head. The Indian women, often barefooted, balance loads on their heads or carry babies on their backs as they walk. The wealthier Mexicans are to be seen on Sundays in Chapultepec Park or on the Paseo de la Reforma, Mexico City, dressed in beautiful brocaded costumes and wide sombreros, riding proudly on horseback. These are the charros famed in picture story.

Every Mexican city has its street market where fruit, vegetables, flowers, and the products of home craftsmanship may be obtained. A few square feet of sidewalk space is all that a Mexican needs to start in business for himself. There is nothing more colorful than the market section. It offers the tourist the opportunity to see a cross section of the life and spirit of Mexico. But the visitor should use discretion in eating fruits, vegetables, or cooked foods purchased there.

THE MEXICAN PEOPLE

Life moves at a leisurely pace across the border and the contrast is very apparent to us from the north. We see the poverty on every hand, but we should realize that there is no heart trouble from overwork in Mexico. They are a people with numerous arts and crafts, but making money is not the primary interest of Mexicans. They love flowers and children—and have plenty of each. They are a courteous people and they usually treat American tourists with interest and respect. Too often the northern tourist is disrespectful of Mexican shrines and customs. A little study of the historical background of the country, of the Aztecs, dating from the year 1300, and of the Spanish conquests, dating from 1521 (the Spanish regime lasted for 300 years until independence was achieved), and of the long struggle for peace and order in the country since that day—all this makes one realize that the Mexican has been subjugated, fleeced, exploited by outsiders to such an extent that it is no wonder that he is a little suspicious of the motives of the foreigner on his soil today. United States enterprise is needed in Mexico as there are tremendous needs to be filled, but Mexico wants to retain the profits of that enterprise. The recent laws forbidding imports of manufactured goods were passed in order to stimulate home industry. The people want and will pay for goods from the United States, but their authorities want them to work for and wait for their own industries to be developed. What the outcome will be, will take years to determine. A large American chain store opened a retail store in Mexico City recently and was given such a welcome that the entire stock was sold out in less than a week. There are, however, no chain stores as there are in the United States.

The shortage of supplies recently has been extended to include such necessary items as electricity and water. Owing to dry weather and its effect on hydroelectric

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plants, a partial blackout was in force last summer in Mexico City. The city was zoned and each zone was cut off for certain hours which were advertised in advance in the daily newspapers. Electric display lighting was forbidden at all times. One shortage which strikes the tourist is the scarcity of clean paper money. Some of the currency in circulation is filthy lucre in more ways than one. But there seems to be no shortage in lottery tickets, and men, women, and children sell them openly on every street.

The tourist suffers no shortage of food or drink. A little caution about eating uncooked fruits or vegetables, or about drinking from regular water supplies, is still in order. There are, however, many good restaurants and hotels available where there need be no concern about what is served (*EE, Feb '48, pp 190-2*).

Mexico is fighting the dread hoof and mouth disease which has been threatening its meat supply. The tourist by automobile becomes increasingly aware of this when he is forced to leave his car when entering or leaving the Mexico Department Federal boundary line to walk through a trench filled with a wet disinfectant. Each automobile is driven through a small lake of the solution before taking on its passengers again.

MEXICO CITY

The city of Mexico (or Mexico, D.F., as it is designated there) contains ten per cent of the population of the whole country, reputedly 2,000,000 people. It is a large city in numbers, but to compare it, for example, with Philadelphia, a city of comparable size, would be rather meaningless. Certainly the automobile traffic is about as bad in one place as the other. The taxi drivers of Mexico are trained to "out-bluff" the other fellow and they do it expertly, leaving the heart of the inexperienced passenger in his mouth most of the time. Many of the streetcars and busses of Mexico are relics of bygone years, and they operate in a fearfully overcrowded condition. The interurban busses are, in general, more up-to-date. The principal railroad station in Mexico City might be compared in size with one in Weehawken, N. J., or San Antonio, Tex., and it probably does not handle any more traffic. The immense Cathedral of Mexico, begun in 1530, has been damaged by the years and by earthquakes and now is undergoing reconstruction which, judging by the present rate of progress may require another century to complete.

Mexico, D.F. (an abbreviation of Federal District), has beautiful parks such as Chapultepec and Alameda; many sightly monuments such as the Memorial to the Founders, Arch of the Revolution, and Juarez Monument; wide boulevards such as Paseo de la Reforma; and a magnificent Opera House in which summer grand opera of the highest order is held. The murals of the great painter Diego Rivera within this building and in the National Palace are worth going miles to see. The city has several large modern hotels and many interesting restaurants and night spots. The western section of the city contains many beautiful modern residences which are festooned with brilliant bougainvillea vines, surrounded by date palms, ornamented with picturesque balconies, and enclosed by decorative iron fences. These Spanish mansions are reminiscent of the best sections of Palm Beach or Miami Beach. Mexico is truly a land of contrasts, and perhaps the greatest of these to the tourist is the wide gulf that exists between the few wealthy Mexicans and the many poor Indians and peons. Labor still can be had in Mexico for the equivalent of one dollar per day, and yet the prices of all needed commodities are as high as in the States. Is it any wonder that many communists have found a refuge there?

THE SIGHTSEER IN MEXICO

Mexico possesses a certain grandeur of scenery that is fascinating to the person from eastern United States. At Monterrey in northern Mexico one first glimpses the rugged mountain peaks through the clouds of early dawn. There Saddle Back mountain appears over the palms of the city. It seems ready to carry the bulk of some legendary giant for a ride through the skies. As the train ascends toward the tablelands to the south, scenes of mountain grandeur unfold themselves in endless variety. At each town the native Indians flock to the station to bargain with the passengers for their wares. Looking over the rough arid land of the valleys, one wonders how in the world they eke out a living in those surroundings. Apparently they depend

Street scene in Taxco (left), and outside the bull ring at Mexico City (right)

on the tourists for that. Near Mexico City the terrain flattens out somewhat, permitting the raising of corn and maguey on a larger scale, and the grazing of cattle. Everywhere the familiar corn stalks and the less familiar spines of the maguey plants are visible.

The real thrill in mountain scenery comes with the first sight of Iztaccihuatl, the sleeping lady, and Popocatopetl, the volcano. Both are more than 17,000 feet high and are covered with snow all the year. Barring clouds, they are visible for an hour on the motor trip to Puebla, and the tourist cannot remove his gaze from them for the entire period.

Farther down, at Fortin, the great snow-covered Orizaba, more than 18,000 feet high, comes into view. Seen from the gardenia-filled swimming pool of the Hotel Ruiz Galinda, it presents a sight never to be forgotten. It is here that fair Mexican maidens enthusiastically drape each newly arrived tourist with a lei of fresh gardenias and they accept no tip. Next morning, however, they sell you orchids. The tropical gardens in this part of Mexico, which is nearer the seacoast and therefore warmer, are of rare charm. Hacienda de las Animas at Cordoba is one of the best of these. Such plants as cinnamon, coffee, sugar cane, pineapple, and banana grow here in abundance.

The trip to the ancient pyramids at Teotihuacan is one that is on the "must list." It is thought-provoking to realize that the Aztecs of Mexico built these monuments to their deities more than 300 years before the Pilgrim Fathers landed at Plymouth Rock.

The short trip to Xochimilco floating gardens near Mexico City is enjoyable. While picnicking on flower-covered flat boats, gondola style, one has ample opportunity to observe Mexican life on a Sunday afternoon on the picturesque canals.

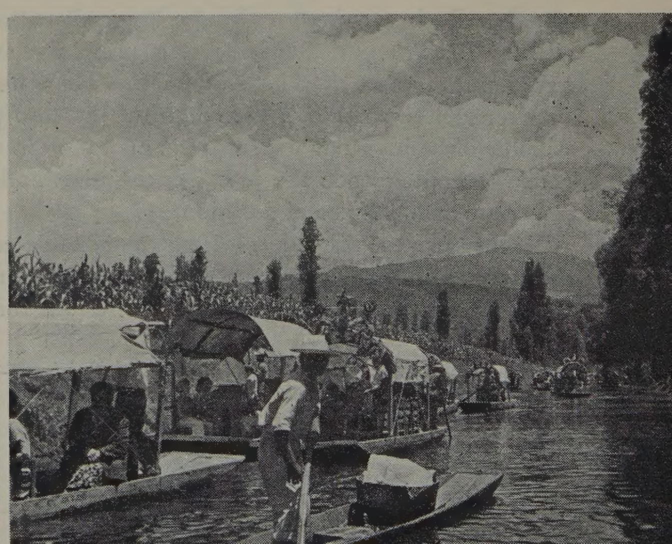
Writing of Mexican life on a Sunday afternoon, one must not overlook the bull fight. Precisely on the dot of 4:00 p.m. there is a hush of the crowd as the first bugle call heralds the entrance of the matadores, the picadores, the bandalleros (and the necessary helpers down to the last man who carries the shovel). They enter the ring in their beautiful brocaded costumes, briefly bow, and then retire before the first bull enters and the fight begins. To sit through the full performance of five of these fights on an afternoon may be a little too much for the novice. Two of them are enough to demonstrate the skill that is required on the part of the performers. And plenty of skill *is* required in studying the behavior of each animal in the ring, in selecting the exact moment and the precise spot in which to pierce him with the sword and the spear. Even those who have an aversion for this typically Spanish sport of bull fighting must admit that it is no more cruel than some prize fights. An ex-bull fighter told me that the bull is so angry that he does not feel the pain anyway. The huge crowd follows the move of their favorite bull fighter with wrapt attention, calling out their approval with cries of, "Olay," and disapproval with whistles and cat calls. They seem to enjoy it and they come back for more Sunday after Sunday.

A motor trip to Cuernavaca and Taxco is, next to the Puebla-Fortin trip, the highlight of a visit to Mexico. It is a 2-day trip and includes a night spent in Taxco. The town remains just as it was several centuries ago. Its narrow cobble-stoned streets, its quaint white houses built on the hillsides with red tile roofs, its old churches, and its market square have a charm about them that once seen never will be forgotten. It is the best place in Mexico to purchase items of silver. Cuernavaca is the city in which Dwight L. Morrow established his residence as ambassador from the United States. He selected Cuernavaca because of its wonderfully equable climate, and he endeared himself to the people there by his many gifts and by his devotion to duty.

In the space of two weeks under proper guidance a traveler may cover properly the principal points of interest in the heart of Mexico and at the same time capture the spirit of a land of primitive peoples who only now are beginning a struggle toward a better life. The experience is sure to make every American more conscious of the great needs of the outside world, and to make him more appreciative of the benefits which he, as a United States citizen, already is receiving.

The AIEE was wise in its selection of Mexico City as the site for the summer meeting in 1948. Anyone who has the opportunity to visit this interesting land either with the engineers, or independently, should not fail to do so.

Monument to the Founders, Mexico City, (left), and at right, the floating gardens at Xochimilco



A Telegraph Signal Analyzer

G. L. ERICKSON
MEMBER AIEE

A portable signal analyzer, for testing the signals on telegraph lines while in use, is a valuable aid in maintaining reliable service. Direct interpretation of recorded data eliminates valuable time previously lost in detailed analysis and calculations.

THE maintenance of accurate and reliable service over modern automatic telegraph circuits has necessitated the development of testing equipment capable of measuring transmission quality and detecting the causes for transmission irregularities. A small portable signal analyzer for field use on start-stop telegraph systems which can test working circuits has been developed. The signal analyzer also has proved very useful in measuring the transmission capabilities of telegraph circuits and investigating the relative importance of the various components that make up the total distortion. Other applications include measurements to determine the condition of signals delivered by transmitting keyboards or regenerative repeaters and tests to check the operation of receiving printers. Measurements are made conveniently, rapidly, and with a degree of accuracy which is ample for all field purposes.

When compared with other test equipment similar in purpose, the outstanding feature of this telegraph signal analyzer is that it has been made very simple and compact and much cheaper. Figure 1 shows a unit in operation testing a printer. During the test period an observation is made of the distortion on every individual signal pulse as it is received. This has the distinct advantage of indicating the effect of occasional peaks, as well as the average distortion, and also makes it easy to identify troubles that occur systematically. The test results are presented in the form of a permanent record on a paper chart which may be analyzed in detail, measured quantitatively, and retained for future reference.

The method of operation takes advantage of the fact that printers most commonly used on start-stop telegraph circuits are the 65-word-per-minute teleprinter employing a 7-unit code and the 60-speed teletypewriter with a 7.4-unit code, both of which transmit basically similar signals. Each employs a 7-pulse "space"-or-"mark" signal for each letter: a spacing start pulse, five intelligence pulses, and a marking stop pulse. The difference between the two codes is the length of the stop pulse, which will be irregular with manual operation in either code. In either code the intelligence pulses and start pulses are of 0.022-second duration.

To measure the distortion it is necessary to determine the amount that any transition (space-to-mark or mark-to-space) has been shifted, remembering that time intervals must be measured from instant of the start transition. In the signal analyzer this has been done by establishing reference points 22 milliseconds apart beginning with the arrival of the start pulse, and by then recording with respect to these reference points all transitions as they occur. A circular paper chart is rotated through one complete revolution whenever a printer character is received, and each signal transition in the code is caused to make a mark on the paper. The departure of these marks from radial lines printed on the chart at 22-millisecond intervals is a measure of the distortion.

MECHANICS OF OPERATION

A start-stop shaft is driven through a slip clutch by a 60-cycle synchronous motor geared down to 420 rpm. The chart is a 4-inch disk of Teledeltos recording paper fastened to a small hub at the end of this shaft. When the selector magnet is energized by a marking stop pulse, the stop latch is engaged to prevent the shaft from turning. As soon as a spacing start pulse arrives, the magnet releases the latch and the shaft is free to rotate while the code pulses for one character are being received. The stop pulse at the end of the character brings the shaft to rest again after the chart has made one revolution.

Meanwhile a stylus in contact with the surface of the disk has been energized by the signals and has recorded a series of black marks on the paper. Because it is desired to record only the transitions between pulses, the recording voltage does not appear on the stylus as long as the tongue of the selector magnet is on either its spacing or its marking contact. But while the tongue is moving through the gap between contacts, the stylus receives a short impulse which lasts as long as the tongue is not touching either contact. As a result, current flows from the stylus to the Teledeltos paper during each signal transition and causes a small black mark to be recorded on its electrically-sensitive surface. The recording voltage is supplied by a rectifier contained within the set.

The recording stylus is moved radially across the

Essential subsance of paper **48-60**, "A Telegraph Analyzer," presented at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948, and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

G. L. Erickson is in the engineering department of The Western Union Telegraph Company, New York, N. Y.

paper from the center of the disk to its outer edge, returns to the center again, and continues to move slowly back and forth in this manner as long as the test is continued. In each trip across the chart, the signal transitions for approximately 190 characters are recorded. Signals may be recorded on one chart for a period of a half hour or longer.

ANALYSIS OF RESULTS

Undistorted signals cause all of the marks made by the stylus to fall on the printed reference lines as shown in Figure 2. With distortion present the transitions will occur earlier or later than their normal times, and will appear on the chart displaced to an extent determined by the amount of distortion. The dotted lines 1 to 5 represent the centers of the intelligence pulses and are helpful in estimating the amount of distortion loss.

Bias, for example, which displaces every signal transition with respect to its position in undistorted signals, is quite simple to detect. Because the mark-to-space start pulse is displaced in the same manner as all the other mark-to-space pulses, bias always appears as displacement of the space-to-mark pulses. Figure 3, *A* and *B*, illustrates this type of distortion. At *B* and *G*, if transitions occur, they must be from spacing to marking. Hence there is only one displaced row of recorded transitions. At *C*, *D*, *E*, and *F* transitions can occur in either direction—the mark-to-space transitions appearing correctly timed, and the space-to-mark transitions being dispaced according to the type of bias present.

Fortuitous distortion (Figure 3*C*) causes the signal transitions to be shifted about in a random fashion so that some transitions are advanced and others are retarded in varying degrees. Should both bias and fortuitous distortion occur, the two components are separated easily because the dispersal of the marks at *C*, *D*, *E*, and *F* is caused by both effects, while that at *B* and *G* is due to fortuitous distortion alone. When characteristic distortion is also present, it can be detected by comparing the results of measurements using different recurring test signals.

In general when there is some irregularity in a sending mechanism, whether it be a printer keyboard, tape transmitter, or regenerative repeater, the defect will be manifest as a systematic displacement of certain transitions. The analyzer provides a convenient means for determining the cause of the trouble and following the effect of steps taken to correct it.

In a commutator-type transmitter the signal pulses are sent from a segmented distributor by a rotating brush arm. If one segment becomes worn or dirty, the sending brush will fail to make a positive contact and the signal will be mutilated every time a marking pulse is applied to that segment (Figure 3*D*).

In a cam-type transmitter the pulses are sent from a set of contacts which are operated in sequence by rotating cams. The signal transitions will be timed improperly if a cam is defective or if a contact spring is out of adjustment. For example, in Figure 3*E* the displacement of transition *G* shows that the start-stop contact always closes earlier than normal. If the start-stop contact opens incorrectly, it will advance or retard the start transition and cause all subsequent transitions to be out of place by a fixed amount.

When irregularities are present in the cams or contacts that transmit the intelligence pulses, the marks recorded on the chart by miscellaneous signals usually will overlap in the manner shown by Figure 3*F*. The

Figure 1. Signal analyzer in operation

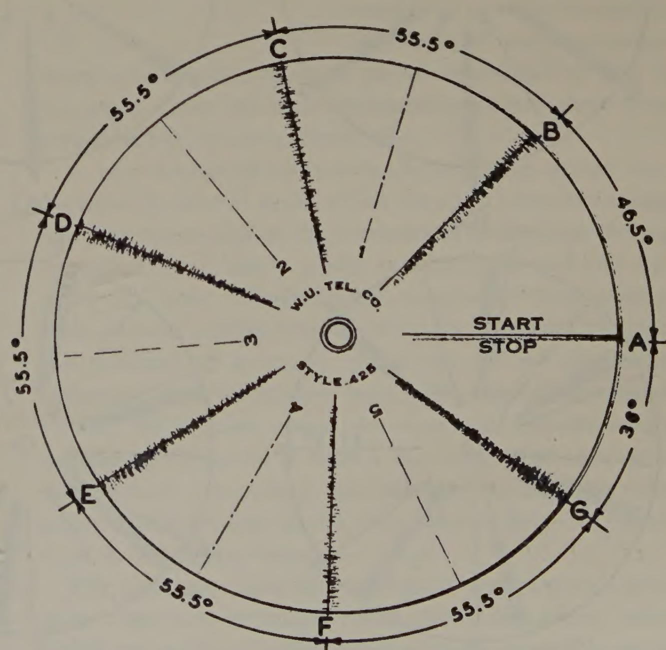


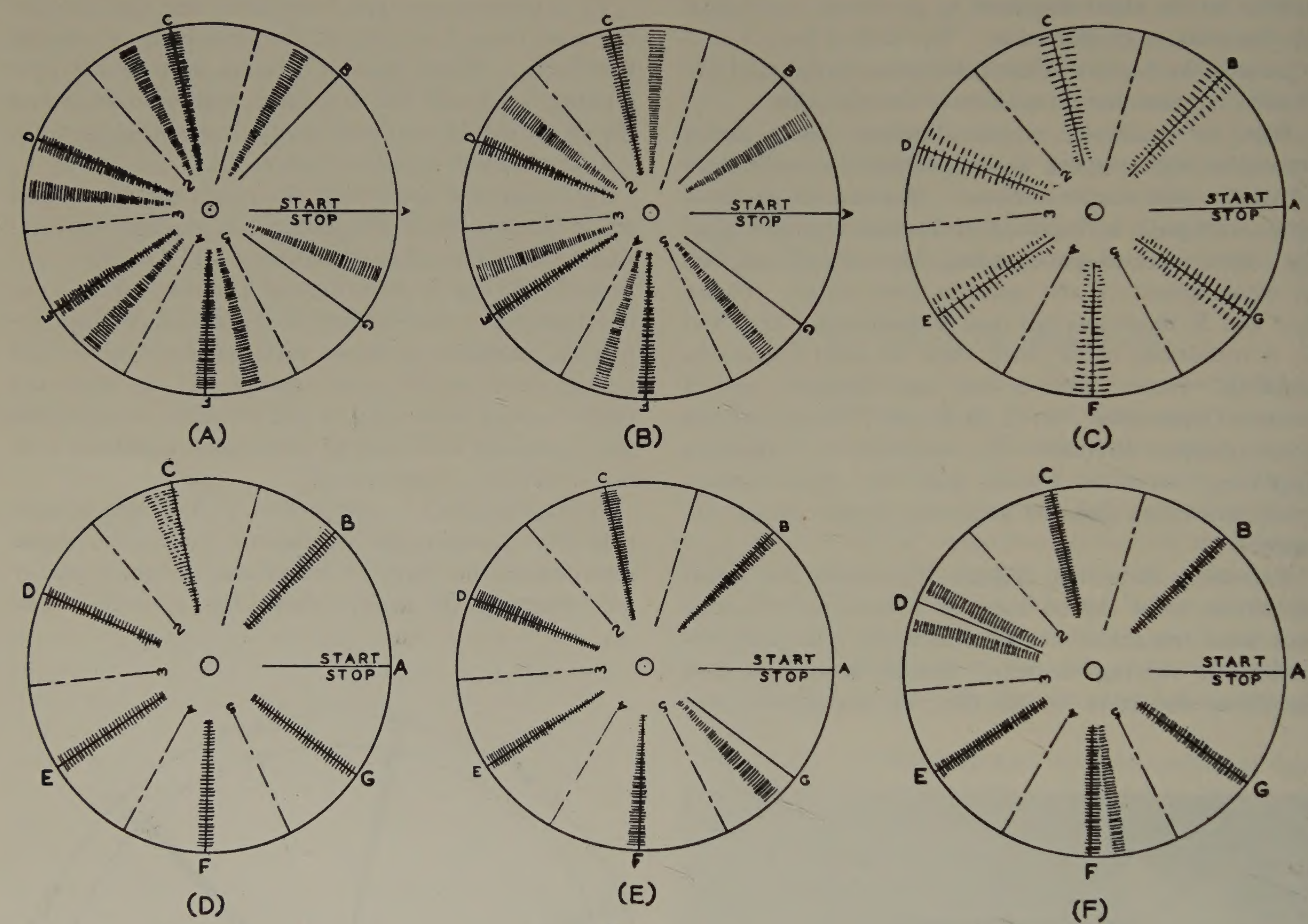
Figure 2. Chart made by perfect signals

double line of marks at *D* indicates that transitions produced by the opening of contact 2 are shifted in one direction while transitions resulting from the closing of contact 3 are shifted in the opposite direction. The marks at *F* consist of one group perfectly aligned and a second group occurring later than normal. Obviously contact 4 is opening too late or contact 5 is closing too late. The exact nature of the trouble readily is determined by observing recurring signals, such as the letter *Y* as compared with the letter *R*.

If the speed of a transmitter is too fast or too slow, the displacement of transitions will be as shown in Figure 3, *G* and *H*, respectively. When the speed is too fast the transitions occur early and the marks are advanced by an amount which becomes progressively greater around the chart. When the speed is too slow the marks are retarded similarly.

The operation of a receiving printer can be checked with the signal analyzer by comparing the signal quality revealed by a test chart with the printing range actually obtainable. A defective printing mechanism is indicated whenever the printer fails to yield the expected range.

Only a few of the more common circuit and equip-



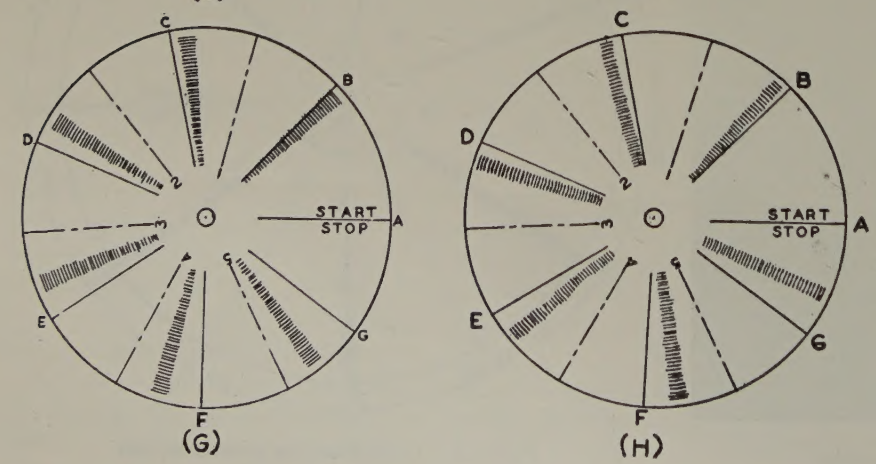


Figure 3. Records of distorted signals

A—Spacing bias of 25 per cent
B—Marking bias of 25 per cent
C—Fortuitous distortion
D—Defective commutator segment for pulse 2
E—Defective stop contact
F—Contact overlap
G—Sender too fast
H—Sender too slow

ment troubles have been illustrated by the chart records presented in the foregoing discussion. The telegraph signal analyzer can be relied upon to disclose any type of signal impairment experienced on start-stop telegraph circuits. In some instances careful study and analysis may be required to diagnose obscure troubles and determine the cause of transmission irregularities revealed by a test chart. Nevertheless, it has been found that operating personnel quickly learn to recognize troubles of the types that frequently are encountered. By comparing test results with sample charts illustrating typical examples, they are soon able to use the signal analyzer to good advantage. When the analyzer is employed to check circuit operation periodically, incipient troubles can be detected and corrected before printing failure occurs, thus assuring a high standard of transmission quality and continuity.

Of course, the analyzer mechanism itself must be adjusted properly if a high degree of accuracy in the distortion measurements is required. However, the device is exceptionally rugged and dependable and requires little maintenance attention once the necessary adjustments have been made correctly. As the analyzer always will reveal its own imperfections, it is only necessary to check its performance from time to time by driving it with a source of perfect signals.

New Speed-Responsive Device for Acceleration Control

A. V. JOHANSSON
ASSOCIATE AIEE

Diesel-electric locomotives now in service using resonant-circuit relays demonstrate the stability of settings and reliability of operation of the new speed-responsive device for acceleration control.

MOST large Diesel-electric locomotives employed in freight and passenger service on domestic railroads have two motor combinations, each with one or more steps of motor field shunting, to provide full utilization of engine horsepower over a wide range of train speed while meeting the requirement that the electric equipment be as light in weight as possible, consistent with good performance. High schedule speeds require that within the limits of adhesion, available engine horsepower be delivered to the wheels at all times during acceleration. To accomplish this it is necessary to change to weak field and to new motor connections at the proper times during the cycle of acceleration. This has been done on freight locomotives by manual selection, with the operator reading a speed indicator and changing his connections at certain train speeds. In passenger service, with its higher acceleration rates and greater schedule speeds, and therefore greater dependence on maintenance of full utilization of engine horsepower during acceleration, it has been found desirable to provide automatic selection of motor connections to relieve the operator of this responsibility and to maintain more uniform acceleration of the train than would be had by manual selection.

A new means of automatically selecting motor connections in several steps, either forward with increasing speed or backward as the locomotive decelerates during operation up a heavy grade, has been devised and applied to new Diesel-electric passenger locomotives. This method utilizes a group of relays energized through the medium of a tuned circuit by an a-c generator mounted on a locomotive axle. Because of the tuned circuit, the voltage across the relay coil increases very rapidly as the speed at which the relay is to operate is approached, providing an inherently accurate and stable speed setting of the relay and a drop-out speed close to the pickup value.

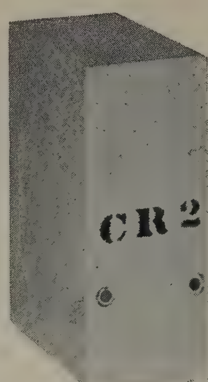
The generator used has a 14-pole permanent-magnet rotor, the output being taken from the stator coils, which are 3-phase Y-connected with the neutral brought out. The generator is bolted to a special cover on the

Essential substance of paper 48-52, "Speed-Responsive Devices on Diesel-Electric Locomotives," presented at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948, and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

A. V. Johansson is a member of the transportation control engineering division of the General Electric Company, Erie, Pa.

Figure 1. Axle generator mounted on locomotive

antifriction journal box on the end of one of the locomotive axles, replacing the journal box cover (Figure 1). The rotor is driven by the locomotive axle through a double-end splined drive shaft. This shaft is designed so that it may be disengaged from the axle, pulled through the rotor, and engaged with a motor-driven calibrating mechanism so that the generator may be operated conveniently for relay calibration without removing it from the locomotive.



The generator energizes the speed relays and, in addition, the locomotive speed indicator. Each speed relay panel consists of one or more reactors, suitable capacitors, a full-wave rectifier, a small hermetically sealed sensitive relay, and a multiple-contact control relay (Figure 2). The control relay, energized by 75-volt d-c locomotive control power fed through the contacts of the sensitive relay, controls field shunting contactors or starts the transition sequence leading to a new motor combination, as the case may be. In addition to the three relay panels required for the two connections of field shunting and the transition, a fourth relay panel may be used to provide a warning of impending locomotive overspeed and to shut off power and apply air brakes in the event of actual locomotive overspeed. The speed indicator is connected between one phase and the neutral of the generator and therefore is not affected materially by the loading presented by the speed relays. The speed relays are connected across two phases of the generator, and operate from the algebraic sum of the voltages produced in each of these phases. The relays pick up at a rather low voltage compared with the maximum reached, and this assures the relays' holding in when the droop in voltage occurs at speeds above the resonant point. It will be noted from Figure 3 that the relays pick up and drop out on a very steep part of the voltage curve, providing an inherently stable setting and a dropout value close to the pickup value. Where required, the drop-out value is raised even closer to the pickup value by means of the insertion of resistance in the coil circuit of the sensitive relay by the control relay operated by the speed relay in each case.

The control relay has a separate cover to prevent the entrance of dirt and the sensitive relay is enclosed in a hermetically sealed can. As the remainder of the equipment is static in type, very little maintenance is required.

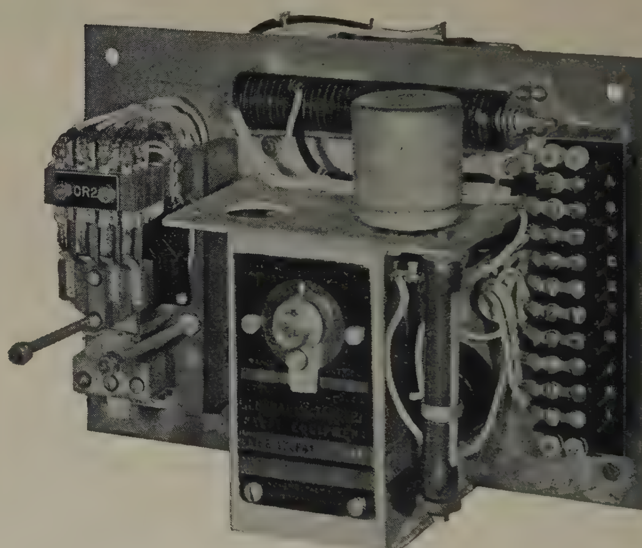


Figure 2. Speed-sensitive relay panel

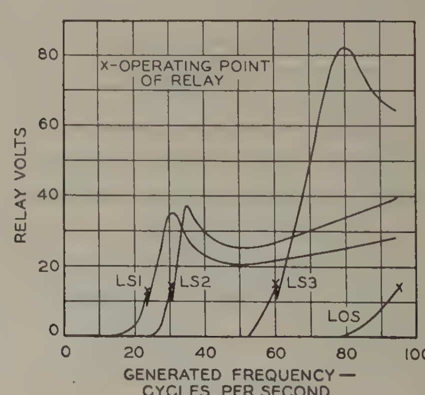


Figure 3. Operating curves of relay coils

Distribution System Modernization

A Symposium

Modernization of distribution systems requires engineering analysis to compare what is being done with what might be done. Often there is neither time nor manpower available when major enlargements are being made to make the extensive studies which seem advisable. Other investigations should be undertaken on a national basis by all the parties involved.

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UNLESS BOTH PARTIES to a business transaction make a gain, the probability of future business is poor. That statement points out that the objective of any distribution system is to give the ultimate consumer the greatest possible amount of the best product with the least cost to the consumer consistent with the cost of production. Electrical distribution has the disadvantage of having a product which is intangible and must be sold on the basis of what the product will do for the consumer in giving him greater comfort, convenience, or production of the consumer's own product. For lack of a better word, this intangible product has been called "service."

Service is a relative thing and does not lend itself to accurate definition or measurement. However, there are limits within which service is acceptable and within which electric systems will accomplish those things for which they are intended. This can be called "adequate service." Adequate service should be the objective of the distribution system, in giving continuity of service, in supplying proper voltage or quality, and in freedom from hazard—all with the greatest consistent economy.

In considering modernization of distribution systems the following objectives and limitations will be recognized:

1. Continuity of service. The nature of electricity is such that it must be available to the consumer at all times with only brief interruptions and as few of these as possible.

2. Economy in a distribution system will consist of a plant which has been built with the least amount of investment to yield adequate service with the least amount of energy losses.

3. Quality of service, which means essentially good voltage regulation. Although uniform frequency is also a quality factor, the control of this function is provided so well that it affords little if any opportunity for modernization.

4. Safety. Because of the constant danger of serious injury and property damage, we continually must strive to reduce and eliminate such hazards, not only to our customers, but also for the benefit of the workmen and the general public.

There is a tendency to consider distribution problems as being rather stereotyped. Without much exaggeration it appears sometimes that distribution engineering is regarded as doing a number of simple things innumerable times and that there are very seldom any new problems and only infrequent chances of finding better answers. However, the first, the most important, and the most fundamental consideration in approaching the problem of modernization of distribution systems is to recognize the fallacy of such thoughts. Distribution more than any other element of the utilities can, and should, benefit from more planned engineering research and analysis. This effort should start with a careful engineering analysis to compare what is being done with what might be done, and to establish the correlation between load densities and the economics of various distribution schemes.

RATE STRUCTURES

Because electrical service is a relatively new commodity, we should not be surprised to discover that with it are elements which were not fully anticipated nor provided for in the pioneer days of putting it on the market.

In the form of wattless power, electric networks are carrying loads which vary from 100 per cent of what they are paid to carry to as much as 500 or 600 per cent and more.

We hardly can hope to go very far toward achieving the utmost economy for the benefit of our consumers under such inequitable circumstances. Nor can we blame either the consumer or the electrical manufacturer for taking advantage of this inconsistency in the principles of billing for service rendered. Distribution systems must be built in recognition of rate structures as well as other factors. We are forced to provide capacity to handle the demand and maintain the voltage within the limits established without regard to the compensation received for supplying these wattless

Essential substance of a conference paper, "Symposium on Distribution System Modernization," and its discussion, presented at the AIEE Pacific general meeting, San Diego, Calif., August 26–29, 1947.

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demands. If we can judge by recent trends this unrewarded effort will be an ever-increasing source of expense and annoyance until the rates fully recognize the costs involved.

CHANGING DEMANDS

Almost all distribution systems require modernization, for there are few systems which have been built with a constant program for culling out the obsolete, the worn out, or the inefficient portions. Many systems (we hesitate to say all) have within them portions which, like Topsy, "just growed." However, the older portions of a system have within them elements which are valuable and cannot be discarded without great waste.

Since the original systems were built there have been increases in load (particularly lagging load), often leading to full load or overload conditions, changes in the types of load (small motors, welding machines, metal furnaces, and line-start motors), and a gradual increase in the demand for 3-phase service. Residential and commercial services also have undergone changes. Lighting and heating loads, while still dominant, no longer have an exclusive claim to service. Small motors, fluorescent lights, washing machine sequence timers, radios, and electric clocks all make demands on voltage regulation and continuity of service.

SECONDARY UTILIZATION VOLTAGE

The present standard of 120 volts has come up from the standard of 100 volts of a few decades ago. There has been an increase of 20 per cent in this voltage level during the time when individual consumer demands have been increasing a few hundred per cent in many instances. Should we not consider perhaps doubling this standard? That is, use 240 volts for the lowest single-phase utilization voltage. Such a change would bring economies not only for distribution facilities, but also for consumer wiring costs. In view of the existing world-wide copper shortage, such a change and the attendant benefits are especially attractive.

In existing densely loaded areas where pole lines have many years of life remaining, it is conceivable that voltage levels could be raised from 120 to 240 volts. This, of course, also would require that consumers convert their facilities, which, in view of their own increasing loads, might be economical.

SINGLE-PHASE DISTRIBUTION

Should we not adopt a scheme of distribution to eliminate the new common practice of dual secondary circuits, one for single- and one for 3-phase circuits? Such a plan could contemplate an initial single-phase secondary system to be expanded to a 3-phase system whenever 3-phase loads were added or whenever the single-phase load density increased to such an extent as to warrant reinforcement of the initial single-phase installation.

Combining these two possibilities it is suggested that either a 240-volt delta secondary system or a 240-and-416-volt Y secondary system merits most careful study and consideration. The Y system appears to be the most desirable. It retains the desirable feature of a grounded system; it brings the greater economies of the higher phase-to-phase voltage; and it eliminates the present duplication in polyphase motor voltages. It is to be noted that, in changing from a 120-and-240-volt 3-wire single-phase secondary system to a 240-and-416-volt Y secondary system, the addition of one conductor of the same size increases the circuit capacity more than five times in terms of kilovolt-ampere-feet for a fixed percentage regulation. The important benefits are not limited to conductor economy alone. There are also such gains as increased diversity as a result of being able to serve large groups adequately from a single transformer installation, and the economy of fewer but larger transformers to provide for the load.

BANKED SECONDARIES

Parallel operation of distribution transformers by means of interconnected secondaries can do much to improve the quality of service rendered. It will afford protection against interruptions because of transformer failures, and greater capacity and hence less voltage flicker when loads are applied. This is particularly helpful in connection with such loads as refrigerator motors. Likewise the interconnections, in effect, tend to put all the load on one source, hence greater diversity is realized and the over-all requirement for transformer capacity is reduced accordingly. The banked secondary scheme permits an immediate modernization of older distribution systems in providing the objectives outlined at the beginning of this discussion. The use of 3-phase secondary systems is also more attractive when secondaries are to be banked. The use of 3-phase secondaries completely removes the unbalance problem which is inherent with banked single-phase systems.

INDUSTRIAL USE OF THREE PHASE

Should our distribution plans contemplate a general practice of supplying 3-phase load over secondary systems from a local source? Considering the loads involved, this "local source" in many instances would be a small station of from a few hundred to a few thousand kilovolt-ampere capacity. One condition which has tended to limit this practice results from the relatively high regulation on such secondary circuits if open wire is used. The old bugaboo, the "wattless component," plays the leading role in this high regulation. We suggest that aerial cable may prove to be a most valuable adjunct for secondary systems in industrial areas. It is interesting to note, for example, when comparing 0000 open wire secondary circuits with 00 cable of 600-volt construction that, for loads with 20-per-cent power factor (inrush power factor for line start

motors and welders), the cable has about twice the capacity of the open wire. Likewise, for the same comparison with 70-per-cent power factor (common industrial average power factor) the cable has about 30 per cent more capacity than the open wire. In each of the foregoing examples the comparisons are on the basis of regulation per unit of kilovolt-ampere-feet. That is, very short circuits, where I^2R losses determine the conductor capacity, have not been considered.

PRIMARY DISTRIBUTION VOLTAGES

During the past few decades primary voltages have been increased as much as fivefold, 4,000 to 5,000 volts now being the common level. During the same period of time, however, the load densities per square mile of area served by these same primaries have increased from 10 to 20 times and more in some instances.

We believe that the possibilities for any material increase in primary voltages are limited by circumstances. These voltages have approached the limit which can be worked safely by hand when energized. Such extensive areas and so many transformers are involved that any radical change likely will be a costly and complicated task. The present levels can be utilized to good advantage for even greater load densities if the primary distribution scheme is modified in accordance with its limitations.

With due consideration for investment in existing systems, should we not adopt a scheme of primary distribution which will eliminate the need for any additional material changes in primary voltage? As one means of accomplishing this we suggest the use of looped primaries, by interconnecting feeder circuits between primary busses of adjacent stations. As an additional means we suggest a basic plan of providing additional station capacity by intercepting existing looped feeders with new stations when required. Such a plan offers more than the means for making present primary voltages adequate. It also provides reserve station capacity by means of interconnections rather than by spare transformers or transformer banks. Likewise, with such a plan the need for high-voltage interconnections and high-voltage protection is reduced and might be eliminated safely in many instances. In place of looped or interlocked emergency circuits on the high-voltage bus to assure adequate continuity of service, we would be substituting lower voltage emergency sources. Consequently, high-voltage protection might be reduced to fuses or eliminated entirely at the receiving station.

SUBTRANSMISSION VOLTAGES

There is also historically a similar lag in the growth trend of the intermediate or subtransmission voltages compared with the loads they serve. Therefore, should we consider adopting some materially higher voltage levels for these purposes, for example 22,000 to 33,000 volts? The choice of voltage for this purpose will be determined in part by adaptability of present voltages to the change. Also, it appears such voltages should be limited to those which can be worked satisfactorily with hot line tools and for which conventional types of cable and potheads are adequate. Where the subtransmission voltage is used for general distribution as well as for subtransmission, the cost of change may exceed the value of advantages gained. However, where loads are heavy and the transformers relatively few in number but large in size it appears that higher voltages may be most desirable.

REGULATION

What should the standard tolerances or allowable regulation be? Should they be fixed or should they be elastic to a degree? Should they allow some appreciable variation over nominal as well as under nominal? It is suggested that the answers to these questions are a most appropriate basis for careful research. A large part of distribution plants is provided primarily to maintain voltage within specified limits. Just what this is worth to the customer is not readily apparent. It well may be that too expensive standards have been set in this matter. Perhaps it would be more economical for the customer to pay more for equipment capable of operating satisfactorily over a wider voltage range, to pay more for energy losses, and not have to pay so much for the more uniform voltage delivery required with less versatile and cheaper equipment operating at higher efficiencies.

One attractive means of providing regulation with a minimum of cost is to obtain more co-ordinated regulation at generation. We suggest that generation schedules for ideal voltage should be co-ordinated with load in such manner that the uncorrected primary bus voltage is nominal voltage plus a few per cent when the load is at maximum, and that it is nominal voltage minus a few per cent when the load is at minimum. It is suggested that such means of voltage regulation is most economical even where it may involve addition of facilities for tap changing under load at generation.

Another possible scheme of regulation may be had with load ratio control or bus-type regulators in lieu of individual circuit regulators. Such a plan would require some change in circuit construction. In place of providing regulation to match the circuit requirements it would be necessary to match the circuit requirements to the regulation provided. Such matching of requirement may be achieved by co-ordinating circuit load and length, by use of fixed capacitor installations, and by use of voltage-controlled capacitor installations.

USE OF CAPACITORS

Capacitors are being applied in large quantities to supply reactive current at or near the load or to induce a voltage gain in circuits where such a gain is desirable.

In addition, capacitors can be used to good advantage in connection with series street lighting loads. They also may be utilized to good advantage on power secondaries near the load, frequently permitting longer runs with satisfactory voltage for starting of large induction motors and providing compensation for any reactive loads on the circuit.

PACKAGE SUBSTATIONS

The use of unit-type substations will become increasingly popular when they are more readily available and eventually will take its place along with other distribution standards. This type of substation installation will afford an ease of location (perhaps in underground vaults or elevated steel platforms) which will become more and more attractive for use in congested areas. We believe that the unit-type station will be most valuable in co-ordination with other plans of modernization.

STREET LIGHTING

Time-clock control, whether spring-actuated or electric-clock-driven, requires considerable maintenance and controlled primary circuits radiating from substations use valuable crossarm space. The carrier-current and relay system (apparently most economical when applied to large systems) and photoelectric cell control (admirably suited to smaller systems) eliminate these disadvantages. Constant current regulators of the moving coil type have a poor power factor and low efficiency and are hazardous because their adjustment must be done while they are under load and energized. There is now available a design of static constant current regulator which has the advantage of high power factor, high efficiency, and no adjustment. However, because of current output variation with voltage input, this regulator is suitable for use only on regulated circuits. Thus, its use must be weighed against the regulator capacity which it demands.

CONSTRUCTIONS

The greater life expectancy of poles with preservative treatment, higher labor costs, and consequent greater investment makes it imperative that more attention be given to obtaining the ultimate pole life with a minimum of changes and retirements in overhead construction. If building or tree conditions or appearance have enough weight, a solution is offered by the use of aerial cable.

Aerial cable installations used for several years in eastern states permit shorter poles in many instances, seem to offer greater reliability, and, in many instances, should permit obtaining the ultimate life from poles already installed where open wire circuits have been subject to outage, where circuits must be added, or where the appearance of open wire may be objectionable.

The availability and consequent prices of metals suitable for conductors seems to be changing. Currently, depending upon the size and type of wire, there is a cost ratio of between 1.25-to-1.00 and 2.00-to-1.00 between copper and aluminum having equal conductivity. The use of aluminum wire having greater conductivity may avoid more changes where existing systems are being modernized.

The various synthetic materials now available ultimately should provide better weatherproof wire because of their homogenous nature and their better resistance to the elements. This should lead to longer life and less expensive installations.

Bare secondary neutral conductors, having high strength for use as messengers, can be used in rack construction to provide pull-off points for services and thus allow poles to be set for the most economical span lengths. Service drop cables also might have bare neutral conductors. The service drop cable offers a solution to tree difficulties and has a better appearance factor.

For underground construction, modernization in the form of modification can reduce the currently high construction costs. Modifications can be made in materials such as the use of synthetic compounds for cable coverings and insulation. It is also possible that the use of aluminum conductors for cables will have to be considered more seriously.

In answer to the demand for systems having better appearance than overhead pole lines, there seems to be promise in the use of modified underground systems with direct earth burial of cables and overhead transformers and cutouts mounted in enclosures above ground.

The factor which has increasing weight in both overhead and underground construction economy is the acceptance and use of standard materials and equipment. These standards have been determined by various organizations of manufacturers and users and should result in over-all economies. However, the use of standard materials always leads to other problems because of local conditions or requirements, and local economies with special material will have to be weighed against the increased costs of the material.

SAFETY

Safety scarcely has been mentioned because of a firm belief that in any part of an electric system safety always shall be considered. We know that certain of our suggestions for modernization will be criticized as being unsafe. To this we reply that energy is always unsafe when it is applied or controlled improperly, but that it need not be used carelessly.

W. J. Walsh
ASSOCIATE AIEE

CONSIDERATION of the desirability of raising present minimum secondary voltage level from

120 to 240 volts, and possibly adopting either a 3- or 4-wire 3-phase secondary system at the higher voltage level, is particularly interesting. The question being asked is, "What is the most economical secondary system to use in light of present and foreseeable future residential loads and service requirements?"

This question arises from time to time, usually during a period of unusual expansion such as many systems are experiencing at present, or when some relatively large new domestic load appears on the horizon. The record indicates that appreciable time is required to establish any considerable saturation of a new type of residential load. Therefore, it is reasonable to assume that time is available in which to study the characteristics of new loads, and adequately examine the question of economical design of the facilities required to serve them.

A considerable amount of study already has been devoted to the subject of economical secondary design. A recent paper[1] presents data to demonstrate that the existing 120- and 240-volt single-phase secondary system is the most economical, and is fully capable of handling any foreseeable load, including heat-pump house heating. However, Blake's analysis, in common with others, is based, of necessity, on certain simplifying assumptions, and does not take into consideration the facilities and equipment required beyond the metering point. An analysis of the over-all system, as well as of secondary design, including utilization equipment and facilities beyond the metering point, would be highly desirable. Obviously, such an involved analysis would have to be made co-operatively on a national basis through representatives of the interested parties.

The use of static capacitors in connection with and switched with series street lighting loads has been practiced with good results since 1941 on the distribution system of the San Diego Gas and Electric Company. In fact, present standard practice calls for installing a 15-kva capacitor with each pole-type constant-current street-lighting transformer, $7\frac{1}{2}$ kva or larger, installed.

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A. L. Williams ASSOCIATE AIEE

IN APPROACHING the problem of the economics of distribution changes we always must keep in mind the fact that no other part of the utility system is so much the product of local factors. The geographic character and extent of the system; maximum and minimum load densities and their contiguous or noncontiguous nature; relative proportion of residential, commercial, and industrial loads and their location on the system; load growth rates and estimated future load densities; and other similar factors all have a profound effect.

This truth throws upon the distribution engineer of any particular utility the responsibility for analyzing proposed changes in practice, or the incorporation of new methods or equipment. How will it affect the existing system? Can that system be modified without undue waste? What will be the effect upon that intangible thing called adequate service? How will it affect operating and maintenance costs? While solving one problem, may it lead to involvement with others? To what extent will it be nonstandard as compared with existing materials now in use in his system, or in general manufacturing production? Those are only a few of the questions that will occur to every distribution engineer when analyzing the desirability or applicability of distribution system modification, even where such changes have been applied successfully on other systems.

It will be recognized that the practicability of many of the suggestions is to a greater or lesser extent dependent upon the determination of some definition as to the practical limits of adequate service. Combined light and power secondaries, bus regulation of feeder circuits, and primary networks would involve, in any economic analysis, a determination of adequate limits of voltage regulation and of satisfactory continuity of service.

In regard to this latter factor, it would seem advisable to investigate more fully, than apparently has been done in the past, the probability of failure in the various parts of the utility system.

Most utilities have, in some place or another, or in some department or another, a mass of lines and equipment failure records that, properly correlated and digested, might form an excellent approach to this problem. Such a study would provide a basis for determining the relative amount of money we are justified in spending in the various portions of the distribution system to provide continuity of service.

The proposal of a 240- and 416-volt Y secondary network system would have obvious advantages as to capacity, first cost, and losses. Because of the changes in standard utilization voltages, it, of necessity, would involve research on a nation-wide basis to determine its over-all economics and the problems that might result: life hazards introduced with the doubled lighting voltage, cost of 416-volt 3-phase motors (particularly in the smaller sizes), and similar allied problems. In view of the difficulties which have attended the standardization of lamp voltages, it appears that the prime consideration would be the cost of obsolescence of consumers' equipment.

The proposal of a subtransmission voltage of about 33,000 volts for serving industrial consumers is in line with the practice established on the City of Los Angeles system.

Distribution system investment per kilovolt-ampere of transformer capacity, and including transformer costs, runs about one-third of the cost on the 4.8-kv

feeder system. There is also a very considerable reduction in losses, and the voltage regulation, while not equivalent to feeder circuits equipped with regulators, is considerably better than the unregulated 4.8-kv circuits used in some instances to supply industrial loads.

Unfortunately, this does not cure the headaches resulting from the present trend of large line-start motors for air conditioning systems in commercial areas where 34.5-kv lines are not available and would involve underground construction for their extension into such areas.

Our practical experience with carrier-current control for street lighting circuits has not been quite as happy as we had anticipated. Although time clocks are subject to high maintenance costs, and switch control wires occupy valuable pole space, the substitution of carrier current in the present state of the art has not been a 100 per cent solution. The primary difficulty has been in securing a dependable relay for field installation that is not too sensitive to mechanical vibration or to voltage variations of the control current. There is also some question as to what effect capacitor devices for power factor correction may have on the required carrier current generator capacity and its voltage at various points on the primary system. Less serious difficulties are the usual ones which attend the adaptation of laboratory equipment to field service.

In spite of these difficulties, however, we believe that the use of carrier current for switching certain loads is fundamentally sound and that it may offer a method for control of other loads such as water and space heating, battery charging, and many industrial processes which can be arranged conveniently for off-peak operation.

At the risk of being termed "reactionary" or "old fogies," we venture to state that, in general, the best distribution system is the one that is simplest in terms of technical design, construction materials and methods, and operation. This does not relieve the distribution engineer from the responsibility of investigating new methods and incorporating them where economies can be effected, service improved, or specific problems solved. If they also improve appearance, all the better.

It was stated that many of our present "headaches" are brought about by the development of utilization equipment that, because of first cost to the consumer, involves a problem for the distribution engineer. As distribution engineers, we recognize the desirability of the increased use of electricity, and our responsibility to provide adequate service. To our mind, however, there is considerable room for a closer co-operation between the design section of the manufacturers of utilization equipment and the distribution design engineer who has the problem of serving this equipment. It seems that in many instances mutual investigation better would balance the savings in first cost of the utilization equipment against the cost of modifying the distribution system to provide satisfactory service. In the long run, the money comes out of the same pocket—that of the consumer.

It is an accepted fact that extensive and expensive research will precede a proposed generation or transmission project, but the distribution engineering staff is usually so limited in number that their desks constantly are piled to overflowing with day-by-day "line" functions that engage their entire time. Perhaps the first step in distribution modernization is to impress upon management that distribution is not stereotyped, and that while its multitude of smaller projects are not as dramatic or spectacular as the generation or transmission project, they constitute a large portion of system investment, involve a major part of system losses, and certainly merit an adequate staff, properly equipped to carry on continuous research in distribution problems.

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1. Modern Secondary Adequate for Coming Home Loads, **D. K. Blake.** *Distribution*, volume 9, number 1, pages 3–5.

Engineering Job Survey

Some interesting results of a survey which polled engineering graduates of June 1947 on conditions of employment were announced recently by New York University's college of engineering, Bronx, N. Y.

The questionnaire was sent out last fall and asked each man for details concerning his position, how it was obtained, what salary was paid at the beginning and later, and whether or not the job is satisfactory.

In 1947, the day division of the college of engineering classified the 107 engineering graduates as follows: 6 administrative, 26 aeronautical, 9 chemical, 15 civil, 14 electrical, and 37 mechanical engineers. Careful analysis of replies with regard to type of employment shows that 79 per cent accepted technical positions in private industry or in civil service; 15 per cent are teaching or are pursuing graduate studies; 4 per cent accepted nontechnical positions (such as sales); 2 per cent are unemployed.

In answering the question, "What was your source of job information?" the results were as follows: 27 per cent—New York University placement bureau; 14 per cent—college of engineering faculty; 18 per cent—personal inquiry; 14 per cent—family or friends; 27 per cent—newspaper, agency or engineering societies.

"Are you satisfied with your job?" brought these percentages: 76—satisfied; 16—not satisfied; 8—undecided.

As to salaries, the average figures reported in various engineering fields were, per month: administrative—$206, aeronautical—$218, chemical—$250, civil—$237, electrical—$257, and mechanical—$247.

Nuclear Engineering

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"Atomic power" depends upon the possibility of producing a chain reaction, analogous to that of burning, which will be self-sustaining. Only when the fission of uranium was discovered did nuclear energy become of engineering concern. This is the fourth in a series of articles developed by the AIEE nucleonics committee.

TO THE familiar subjects of engineering—civil, mechanical, electrical, electronic, and chemical—a new field has been given us by the physicist: nucleonics or nuclear engineering. This can be defined as the art of applying nuclear transmutations of matter to useful purposes. The subject of nuclear engineering, which has been developing gradually over the past 15 years, is in everybody's mind because of its application to the making of the atomic bomb and present experimentation with nuclear reactors by the United States Atomic Energy Commission.

All energy used industrially comes either from the work done by falling water or from the combustion of fuels—coal and petroleum products principally. The outstanding characteristic of combustion (or other chemical energy) is that the atoms involved in the combustion process are not changed intrinsically. Atomic energy is the energy associated with changes in the basic chemical nature of the atoms. The energy release in nuclear reactions is, generally speaking, of the order of millions of times the energy, weight for weight, released in chemical reactions.

WHY IS NOT ATOMIC ENERGY OBTAINABLE PRACTICALLY BY "NUCLEARLY BURNING" OF HYDROGEN AND LITHIUM TO FORM HELIUM?

The answer is furnished by comparison with coal. Coal (or any other chemical fuel) is valuable not only because of the energy release, but also because a self-maintaining fire can be made in which carbon and oxygen continue to burn. Of what use would coal be if a thousand dollars' worth of matches were used to burn a ton of coal? That was essentially the situation confronting physics in all nuclear reactions prior to discovery of the phenomenon of uranium fission in 1939.

To make hydrogen atoms react with lithium, for example, it was necessary to ionize them and accelerate them in some kind of high-voltage apparatus. Of the many accelerated, only a few struck lithium atoms in such a way as to react. The energy used to accelerate the others was wasted. The net result was that more energy was used in the experiment than was released.

Hence, from 1932 to 1939, we were in the position of knowing that large energy releases were possible from many different nuclear reactions, but these could be produced only in laboratory devices that required more energy for their operation than was liberated by the nuclear reactions.

HOW DID URANIUM FISSION CHANGE THIS PICTURE?

However, as soon as the work of discovery of uranium fission reached the United States from Germany in January 1939, it was realized by physicists that the possibility of getting atomic power in useful form was within reach. The nature of uranium fission is a key factor in this picture.

When a neutron strikes a uranium nucleus in the right way, the nucleus breaks up by falling apart in two approximately equal fragments with the release of about 200 million electron volts per atom split. Great as this is, it is no better, weight for weight, than the reaction that forms helium from hydrogen and lithium; in fact it is only about half as good from an energy release standpoint.

The essential thing about uranium fission is that the uranium atom falls apart in such a way as to liberate several more free neutrons. It is this neutron liberation that makes a self-maintaining process possible. The splitting requires a neutron to make it go—and the splitting process itself acts as a source of neutrons which can cause more uranium atoms to split. Here is the basis of a self-maintaining process, technically known as a chain reaction, analogous to ordinary combustion.

WHY, THEN, DOES NOT ORDINARY URANIUM EXPLODE, OR AT LEAST "BURN NUCLEARLY?"

There are complications. Because several neutrons are released at every fission, a chain reaction is possible. But to make it an actuality, one of the several neutrons released actually must produce another fission to keep the process going. Otherwise the nuclear "fire" goes out.

If all the neutrons released produced more fissions the material would explode violently. But because neutrons move rather freely through matter (like X rays), many are lost by escaping through the surface. The solution is the use of a large enough aggregate to get a smaller surface-to-volume ratio. In other words, unless the aggregate of fissionable material exceeds a

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certain critical size the chain reaction cannot proceed.

Another complication is that certain impurities in the uranium have a bad effect by absorbing neutrons. This is very difficult to remedy, for appreciable losses result from the presence of only one part per million of some materials, and it is no easy matter to manufacture anything of that purity on an industrial scale.

The worst complication of all is that uranium itself absorbs neutrons in other ways than those that produce fission. This phenomenon was both a blessing and a curse to the aims of a military project. It turns out that the over-all effect of this nonfission absorption of neutrons by uranium is sufficiently great to prevent the explosion of perfectly pure uranium even in so large a lump that escape of neutrons through the surface is negligible.

Neutrons given out in the fission process are "fast," that is, have speeds corresponding to several million electron volts of kinetic energy. Such fast neutrons colliding with uranium atoms have a rather great chance of losing energy without being caught and without producing fission.

Neutrons of intermediate speed produced in this way are unable to produce fission in ${}_{92}U^{238}$. They can do so only in ${}_{92}U^{235}$, which forms only 1/140th part of natural uranium.

Neutrons of a particularly low energy (about ten electron volts) are very likely to be captured by ${}_{92}U^{238}$ to form ${}_{92}U^{239}$, a very important phenomenon which will be considered later. This happens so readily that enough neutrons are used up this way so that a chain reaction cannot be maintained in ordinary uranium.

An uncaptured neutron continually loses energy by colliding with atoms as it diffuses throughout any material, until its average energy is that of the heat motion of the atoms of the material. Neutrons of certain extremely low energies are captured strongly by U^{235} to produce fission.

To achieve a successful chain reaction with ordinary pure metallic uranium, which contains all kinds of uranium atoms but is predominantly ${}_{92}U^{238}$, the uranium was arranged in a lattice of small lumps so that many of the fast-moving neutrons would diffuse out of the uranium into some surrounding material. Here many of them would be slowed down before diffusing back into the uranium. The idea was that most neutrons thus would escape being caught by ${}_{92}U^{238}$ until they had lost so much energy that capture by ${}_{92}U^{238}$ was unlikely. Ultimately, though, they would return to the uranium lumps and sufficiently have reduced speed to cause fission in ${}_{92}U^{235}$.

In the technical vocabulary of nuclear engineering this other material, which keeps neutrons in custody and helps them lose energy until they are safe from capture by ${}_{92}U^{238}$, is called the moderator. Evidently the moderator material must not absorb too many neutrons or the reaction will be stopped by this circumstance. Graphite finally was adopted as a moderator, although not until processes were developed for manufacturing it to much higher standards of purity than is usual in ordinary industrial practice.

As this qualitative picture evolved prior to January 1942, the question of whether a chain reaction would go remained unanswered because of lack of exact quantitative knowledge of the various absorptions involved. But as knowledge accumulated, it became more and more probable that such a lattice of uranium lumps and moderator—now called a pile—would go, that is, a chain reaction continuously releasing atomic energy by fission of the ${}_{92}U^{235}$ would be self-maintaining.

HOW CAN THE PILE BE KEPT FROM BLOWING UP?

If a pile is so arranged that, on the average, more than one fission results from the neutrons produced by each fission, then clearly the number of neutrons present, and the amount of heat generated, increases by the compound-interest law. If a great multiplication happens rapidly—say in a small fraction of a second—then the phenomenon becomes an explosion. In short, we have an atomic bomb. Even if the reaction occurs slowly, the pile soon would be destroyed by melting if the multiplication were allowed to proceed.

One way to control the pile is to provide passageways through it into which rods of material that strongly absorb neutrons can be placed. When these rods are in, they absorb so many neutrons that the chain reaction is stopped. As they slowly are withdrawn, a point is reached at which the reaction is just able to proceed. If pulled out farther, the neutrons are able to multiply more rapidly and the pile operates at a higher power level. To stop the pile, the absorbing rods simply are pushed back in farther. Cadmium and boron-containing steel are suitable materials for the control rods.

The language of the preceding paragraph implies that the time scale is slow enough for an operator to maintain control by manual operation of the rods or by use of a similar slow-acting control mechanism. That is, in fact, the case because of another phenomenon in the fundamental physics of fission: delayed neutrons.

It was discovered in May 1942 that most, but not all, neutrons emitted in the fission process come out instantly. The uranium nucleus in splitting apart spills out some neutrons immediately. But the atomic fragments formed are also in a highly unstable condition, and some of them throw out additional neutrons after a short time delay, amounting on the average to half a minute. It is the delayed ones that set the time scale on which the neutron multiplication in the pile builds up and set it for such a long time that slow-acting controls are easily able to regulate the activity of the pile.

In summary, it should be remembered that, although a pile is built with ordinary uranium, it is only the 0.7 per cent of the metal that is ${}_{92}U^{235}$ that is active. The ${}_{92}U^{238}$ that forms most of the metal actually tends to stop the process. Only by ingenious lattice arrangement

for slowing neutrons in a moderator is the pile able to operate in spite of the presence of the more prevalent $_{92}U^{238}$.

This means that, regarded as a fuel, only 1/140th of the total weight of uranium is being used directly; the rest is an inert material that remains largely untransformed by the pile.

HOW DOES THE ATOMIC BOMB CHAIN REACTION DIFFER FROM THAT IN THE PILE?

The atomic bomb explodes, whereas the reaction in the pile proceeds in a slow way easily controlled by manual operation of absorbing rods. The fundamental distinction is that the bomb (one type) is made of essentially pure $_{92}U^{235}$ and without the use of a moderator. The chain reaction in the bomb is carried on by fast neutrons directly released by fission. As already remarked, this cannot happen with ordinary uranium because the $_{92}U^{238}$ slows the neutrons to the point where they cannot produce fission in $_{92}U^{235}$ and also absorbs many of them. With essentially pure $_{92}U^{235}$ these competing absorption processes do not occur, and the reaction is carried by the fast neutrons directly emitted from a $_{92}U^{235}$ fission. These are utilized at once to produce fission in other $_{92}U^{235}$ atoms. Here the main factors tending to stop the reaction are the loss of neutrons through the surface (which sets a minimum size to the bomb) and losses by absorption by impurities including any remaining $_{92}U^{238}$.

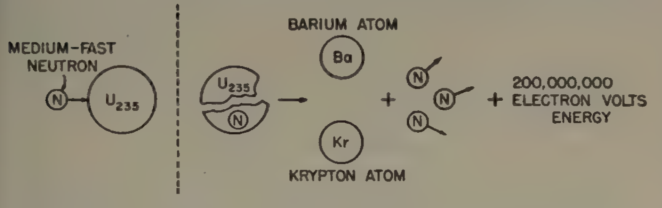

Figure 1. Release of atomic energy depends on fission

A neutron moving with the right velocity strikes a uranium 235 atom (or plutonium atom), which breaks into two middle-size atoms with a total mass slightly less than the mass of the disintegrating atom. The mass difference appears as a large quantity of energy

WHAT IS PLUTONIUM?

This is a newly discovered chemical element not known to exist in nature but which is made from uranium by atomic transmutation. Plutonium is important because it, like $_{92}U^{235}$, is a material from which atomic bombs can be made.

That $_{92}U^{238}$ can capture neutrons already has been mentioned as a phenomenon detrimental to the operation of a pile. When $_{92}U^{238}$ captures a neutron it becomes $_{92}U^{239}$ and emits gamma radiation as does radium. $_{92}U^{239}$ is not stable but emits high speed electrons by a process of spontaneous radioactivity. The mean life of the $_{92}U^{239}$ atoms is only about 20 minutes. By this activity they are transformed into atoms having essentially the same mass but one greater positive charge in the nucleus, and hence into a new chemical element. It is called neptunium, $_{93}Np^{239}$. Neptunium 239 is also spontaneously radioactive and emits another high speed electron, becoming thereby an atom having 94 positive charges on the nucleus but still essentially of mass 239. This process is slower; the mean life of the neptunium atoms is about two days. The resulting atom is another new element that does not occur in nature. It is called plutonium and written $_{94}Pu^{239}$.

WHAT OF THE FUTURE?

Atomic energy has many potentialities that may be expected to affect industry profoundly in the course of several decades. While no reputable scientist ever makes definite promises about anything that lies in the future, still it is possible to venture an opinion that the following significant developments are highly likely to be made within the next ten years:

1. More effective ways of producing $_{92}U^{235}$ and $_{94}Pu^{239}$ will be developed, permitting greater production at lower cost.

2. These materials in combination with ordinary uranium will make possible power-producing piles of smaller size than those thus far developed.

3. Piles will be developed for important peacetime uses as special-purpose energy sources, and as sources of neutrons and radioactive materials for medical and other scientific work.

4. Piles probably will not be developed into small power units for automobiles or airplanes because of their over-all weight, including that of the material needed to shield the passengers from the dangerous radiations.

5. Also because of shielding difficulties, piles probably will not provide the driving power for railroad locomotives. However, it is reasonable to suppose that within a decade some ships may derive their power from piles.

Besides uranium it is known also that fission may be produced in thorium, which is much more abundant in nature than uranium and therefore may be the fuel in piles of the future. Whether release of atomic energy from other materials can be achieved is a question

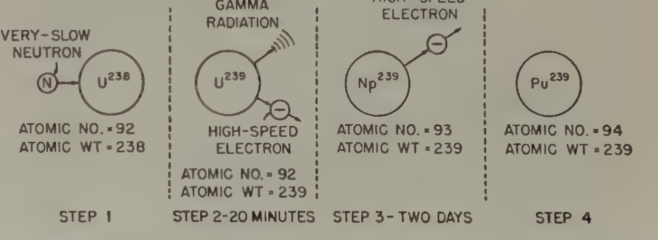

Figure 2. Plutonium is made by a 4-step process

$_{92}U^{238}$ absorbs a slow-moving neutron. The product emits two electrons successively, resulting in a new element of higher atomic number and mass than occurs in nature

which can be decided only by future research. At present no means of doing this is in sight, but it should be remembered that in 1938 the atomic bomb would have seemed fantastic to the best nuclear physicists.

The physical problems of an atomic pile largely have been solved and the problems of an atomic energy plant are engineering ones—principally the transfer of heat from the pile to a cooling fluid and the conversion of this heat into power. Three atomic power plants are now under way—at Oak Ridge, Tenn., Chicago, Ill., and Schenectady, N. Y.—and it should be possible to realize experimental production of power within a year or two. Of course, energy production from atomic piles has been an actuality for several years, but the energy release in such piles has been in the form of low temperature heat.

The substances suited for the production of heat by nuclear fission are ${}_{92}U^{235}$ and ${}_{94}Pu.^{239}$ Natural uranium, ${}_{92}U^{238}$, is useless for direct fission. Only ${}_{92}U^{235}$ exists in sufficient abundance in nature for practical purposes, but it exists mixed with natural uranium and separation is both costly and tedious. On the other hand, separation of ${}_{94}Pu^{239}$ from natural uranium is simpler because it is concerned with different chemical elements. The atomic power plant, for reasons of economy and efficiency, probably thus will utilize the relatively abundant ${}_{92}U^{238}$ with its 0.7 per cent of ${}_{92}U^{235}$. For a continuous chain reaction, the pile will be large—of the order of several tons—unless it is enriched by the addition of ${}_{92}U^{235}$.

Another article of this series will discuss the engineering applications of nuclear energy.

Electricity Aloft

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A modern airplane may include as many as a hundred devices requiring electric power. The development of electric systems for aircraft and the present status of electric auxiliary-power systems will determine to a great extent the kinds of systems that will be used tomorrow.

THE HISTORY of the development of aircraft auxiliary power starts many years before the first airplane, with the development of man-carrying balloons. It is believed that the first application of auxiliary power on aircraft was the use by the Montgolfier brothers, in 1783, of a pan of fire hung under the open mouth of their balloon to keep the air inside hot and, therefore, light.

The first recorded use of electric drive for aircraft occurred in 1882, when Gaston Tisandier used an electric motor, powered by a storage battery, to drive a propeller on a balloon.

The airplane made its appearance in 1903. The airplane in which Professor Langley crashed into the Potomac, and the airplane that the Wright brothers flew at Kitty Hawk in 1903, were light, flimsy craft, with no room nor need for auxiliary power, other than the magneto for the 16-horsepower engine. Modern development of auxiliary power in aircraft may be said to date from installation of radio equipment in 1917.

SOURCES OF ENERGY

Before considering the development of aircraft auxiliary-power systems, it will be well to pause and consider the sources of energy available for driving these auxiliaries.

1. Human energy, applied by means of hand and foot controls, hand pumps, levers, and so forth, may be the only power available for operating auxiliaries on a very small airplane. On large airplanes, the amounts of power involved are such that other sources of auxiliary power are required. On very large airplanes, auxiliary power even may be required for movement of the control surfaces.

2. The air stream was thought by early designers to be the ideal source of auxiliary power, perhaps with the idea that the power was available for practically nothing. Most of the early designs called for wind-driven generators. Air scoops still are used to provide pressure to force cooling air through equipment, and to feed air to the carburetors. Wind-driven generators, however, have been abandoned. They have been found to be a very inefficient means of converting power, creating a drag which is excessive for the amount of power obtained.

3. The main engines are by far the most common source of auxiliary power. "Take-off pads" are provided on engines for attaching pumps, generators, magnetos, and so forth. This

Essential substance of miscellaneous paper 47-214, "Electricity Aloft," presented at the AIEE Middle Eastern District meeting, Dayton, Ohio, September 23–25, 1947.

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source has been very practical for d-c systems, in which the generators may operate at any speed, to conform with the engine-speed requirements of flight. The space behind an engine is very crowded, however, and equipment mounted on the take-off pads is subject to severe vibration caused by the engine. This vibration, coupled with the necessity of supporting the generator by a flange on the end, imposes severe limitations on the capacity and design of the generator.

4. Separate auxiliary-power engines may be installed. Small reciprocating engines are heavier, in terms of pounds per horsepower-hour, than larger engines, and introduce problems in supercharging. The flexibility of auxiliary-power-unit installations offers several advantages which tend to offset these factors:

(*a*). It simplifies parallel operation of generators, especially a-c generators.
(*b*). It permits the operation of generators independent of the operation of the propulsion engines.
(*c*). It permits the location of the auxiliary-power units where they are readily accessible for maintenance in flight.
(*d*). Generators which only are required to operate at one speed can be built lighter than generators which must deliver rated output over a wide range of speeds.

Gas turbines, now in the development stage, offer considerable promise as an alternative prime mover for auxiliary-power units.

TYPES OF ELECTRIC SYSTEMS

Following the developments which occurred during World War I, the development of electric systems for aircraft proceeded in a very hit-or-miss fashion. The demands of various aircraft, used for different purposes, varied widely. There was little incentive, prior to World War II, for standardization, and a number of systems were developed.

D-C Systems. The first power systems were used mainly for radio and instruments and were designed to use an automotive-type 6-volt storage battery with an 8-volt charging generator. Systems employing 12-volt batteries and 14-volt generators were inaugurated about 1920. They proved very satisfactory for small and medium-sized airplanes and were still in common use at the start of World War II.

As the loads of the electric system increased, the weight of wiring required for the 12-volt system became prohibitive. In 1939, new airplanes were being designed with electric power systems using 24-volt batteries and 28.5-volt generators. To eliminate serious problems in the supply of maintenance parts in the field and the complication of training repair crews to service both 12- and 24-volt systems, constant pressure was exerted to achieve standardization on a 24-volt system.

Electric loads and distances over which power must be transmitted have continued to grow, reaching enormous proportions in some of the new and larger airplanes. Several of the large airplanes have been designed to use 120-volt systems, thereby reducing the copper required and increasing the efficiency. Results have encouraged further development of the 120-volt system.

A-C Systems. A-c power systems for aircraft date back to the days of World War I, with the development of the wind-driven 200-watt 900-cycle alternator. In 1930 this machine was redesigned to deliver 600 watts continuously at 800 cycles and 4,000 rpm, with a peak load capacity of 1,200 watts. In 1931 a similar generator was used with transformers and rectifiers, to develop a source of 2,000-volt d-c power for the Navy. The Navy believed that this system was far more satisfactory and reliable than the 1,000-volt d-c generators which it had used.

As power demands on aircraft increased, engine-driven generators were developed with separate a-c and d-c windings in the same frame, in which variable-frequency alternating current is rectified at high voltage for the plate circuits, and is used at low voltage for the filaments. The d-c output of the generator is used for general purposes on the airplane and for relays, lights, and so forth, in the radio equipment.

Recently there has been an intense revival of interest in the possibility of utilizing the advantages of a-c power distribution, as the loads carried and the distances over which the power must be transmitted have grown to proportions which make these advantages more apparent. Such advantages as the ability to use small, light, rugged transformers to obtain a variety of voltages, including the high voltages required for radio plate circuits, the simplicity of the squirrel-cage induction motor, and the elimination of commutation and brush-wear problems at high speeds and high altitudes have contributed to this interest in alternating current. Even though equipped with d-c electric systems, most modern aircraft have instruments and equipment which require alternating current for their operation, and so must be equipped with rotary inverters for supplying the a-c power from the d-c line.

Early a-c systems used frequencies in the vicinity of 800 cycles, which seems to be about the optimum frequency for minimum weight of transformers, and similar apparatus. Generators and motors with large numbers

Figure 1. Wind-driven generator

Table I. Comparison of Weights of Aircraft Electric Systems as Applied to 150,000-Pound Airplane with 60-Kw Continuous Load

All numerical values are in pounds

Components	System: 28-V D-C	120-V D-C	120-and-208-V 400-Cycle 3-Phase
Generator weight, one	135	120	75
Voltage regulator, one	6	6	9
Main generator circuit breaker, one	6	6	5
Drive shaft from engine	15	15	15
Constant speed drive			75
Total, one engine	162	147	179
Total, four engines	648	588	716
Batteries	55	55	55
Two 6-kw 28-volt d-c supplies		75	75
Two 5-kva a-c sources	150	148	
Wiring	420	55	65
Total weight, generation and distribution	1,273	921	911

of poles or extremely high speeds are required with 800-cycle systems. The synchronous speed of a 2-pole 800-cycle alternator is 48,000 rpm. Designers considering the use of a-c systems calculated that the optimum frequency for motors, to obtain minimum weight, was about 270 cycles, based on speeds that then were considered practical. It was obviously necessary to arrive at some compromise, and establish a frequency that would be used universally, to promote interchangeability of equipment. The aircraft and aircraft equipment manufacturers, the Army and Navy, and the British Air Commission decided in favor of a 400-cycle 3-phase 4-wire 208-and-120-volt system.

The *XB-19*, one of the first 400-cycle installations which flew in 1941, was not especially successful; but in revealing the problems to be solved, it contributed a great deal to the knowledge and experience which has been the basis for further development. Much since has been accomplished toward solving the problems encountered in this installation.

Modern a-c electric systems for aircraft are centered around three types of drive:

1. *Main Engine Drive.* It has been standard practice, with d-c electric systems on aircraft, to use generators driven by the main propulsion engines. The use factor of the main engines is improved slightly, and the large main engines are more economical of fuel per horsepower-hour than smaller ones.

The use of main engines for driving alternators to be operated in parallel on a constant frequency system introduces a requirement for some kind of "constant speed drive" to convert the varying speed of the engines to constant speed for the alternators. They must convert both speed and torque, to avoid the waste of large amounts of power. (Where parallel operation is not required, it might be possible to hold the frequency within a usable tolerance by means of a gear shift, as in an automobile transmission.) Several torque converters have been designed to meet these requirements, of which the Sundstrand drive is probably the most widely known. This is an ingenious device, employing a "wobble-plate" pump and a "wobble-plate" motor, as shown in Figure 2. The pump wobble plate is an inclined plane, the angle of which is controlled by the governor. The only work done by the hydraulic system is that required to introduce a difference in speed between the input and output shafts. The body of the hydraulic unit contains the pump and motor cylinders and pistons, a chamber in which oil is maintained at a pressure of 250 pounds per square inch by a makeup pump (not shown), a transfer chamber through which the oil passes from the pump to the motor, and simple ring-type valves for connecting the cylinders alternately to the oil supply and the transfer chamber. As the pump rotates the pistons move in and out, maintaining contact with the sloping surface of the wobble plate. The pistons are forced out by the pressure of the oil supply. On the return stroke the cylinders are connected to the transfer chamber, the pressure of which depends upon the requirements of the motor. The action of the pistons, sliding on the inclined surface of the wobble plate, is positive, so that the volume of oil delivered is controlled by the position of the governor. The pressure is that required to operate the motor, which depends upon the load. The motor works on the same principle. The pistons, forced out against the wobble plate, slide down the inclined plane, causing it to turn with respect to the body of the hydraulic unit. This rotation adds to that of the body of the unit, so that the output shaft is driven at a speed higher than that of the input shaft. The oil from the motor is discharged into the supply-oil chamber. If the input speed is higher than the desired output speed, the pump wobble plate is moved past the vertical position, causing the oil to be pumped in the opposite direction, which, in turn, causes the motor to rotate in the direction opposite to that of the body of the unit. The motor rotation then is subtracted from that of the body.

For use with the constant-speed drive, 3-phase 400-cycle 6,000-rpm 8-pole 208-and-120-volt alternators have been developed to deliver 40 kva continuously. Although the watts loss per pound is very high—the machine is blast-cooled—the weight is only a fraction of that of the corresponding 60-cycle machine, and the efficiency is higher. This weight reduction is accomplished by the use of higher operating speeds and temperatures, higher current and flux densities, and other refinements in design. Heavy damper windings are used to simplify synchronizing.

2. *Auxiliary-Power Engines.* At present, the standard source of 400-cycle power for aircraft systems employs 14-pole or 16-pole generators, running at 3,428 rpm and 3,000 rpm respectively, powered by aircraft engines. Most of these have been 32.5- or 62.5-kva 208-and-120-volt 3-phase machines. Many of these alternators are installed in aircraft, including the *XB-35*, the *XB-36*, and the first *Constitution.*

3. *Gas-Turbine.* The gas-turbine power plant is a very promising development. The gas turbine, like the modern steam turbine, is essentially a constant-speed device, ideal for driving an alternator. The flow of power is smooth, in contrast with the torsional vibration of the reciprocating engine. It is a high speed machine, and can be designed for operation at speeds of 12,000 or 24,000 rpm, as compared with the speeds of 2,000 to 3,000 rpm common in reciprocating engines for aircraft. Voltage control is obtained in each instance with a carbon-pile voltage regulator, similar to the regulators used on d-c generators. Alternator terminal voltage is sampled through a 3-phase transformer and a 3-phase full-wave selenium rectifier. The regulator controls the field of the d-c exciter generator (about eight amperes) instead of trying to control the rather large field current of the alternator (about 60 amperes) directly. This not only reduces the current that must be handled by the regulator, but it also makes for a system that will maintain its voltage under fault conditions, making it easier to clear the fault without losing the rest of the load.

If parallel operation of alternators is required, another circuit, commonly known as a reactive-load-division circuit, is included, which "sees" only the difference between the current output of the alternator with which it is associated and the average output of the alternators on the line, further analyzes this difference, and applies a signal to the voltage-control circuit which reduces

the voltage if the alternator is carrying more than its share of the reactive load, and conversely. The signal resulting from the real load is applied in such a way as to have no effect on the output voltage. Real-load division must be accomplished by the speed governors, as in all alternator installations.

WEIGHT

All aircraft designs must hold weight to a minimum. Although safety and reliability are of undisputed primary importance in aircraft, every pound that is added to the weight of an airplane, not compensated for by added driving power, must mean a reduction in the pay load of the airplane. The reduction in operating revenue by removing a pound from the allowable pay load amounts to $100 to $200 a year.

A careful study of the comparative weights of the generating equipment and distribution systems for each of three possible systems in a proposed 4-engine 150,000-pound airplane is tabulated in Table I. The continuous electric load was 60 kw, requiring four 30-kw generators for peak load and safety, each capable of carrying 50 per cent overload for five minutes. This provided an intermittent duty reserve capacity against failure of or combat damage to generators in flight and for the extra loads which always are added to a military airplane before it leaves the manufacturing plant and the modification center.

In this comparison, the saving in weight with the a-c system, as compared with the use of the 120-volt d-c system, is too small to be conclusive, especially as the further development of both of these systems will result in further weight reductions.

This analysis does not include the weight of the utilization equipment or of instrument wiring. There is not much to be saved in instrument-wiring weight—in fact, many of the instruments now are operated with 400-cycle a-c power furnished by inverters. However, substantial savings will be realized in the weights of some of the equipment, by the use of such devices as the induction motor and the transformer.

The a-c system compares very favorably with the d-c system in regard to reliability. The squirrel-cage induction motor, requiring no brushes or commutator, is an extremely simple, light, and rugged device, and can be built for very high speed operation, 24,000 rpm being the maximum speed for a 400-cycle motor. Alternators require brushes only to carry the field current to the rotor, through slip rings. Voltage control circuits are only required to handle the field current of the exciter—generally much less than 10 amperes. Transformers are extremely simple and rugged, and a 400-cycle transformer weighs only a fraction of the weight of a 60-cycle transformer.

TOMORROW

It seems reasonable to infer that the same type of system will not be used on all of the many types of aircraft. There is too much difference in the size of airplanes and in characteristics of installed loads to expect one type of system to be the optimum design for all.

Small Aircraft. The small private aircraft, commonly called "puddle-jumpers," will be produced in quantities far exceeding all of the other classes combined, and probably will be serviced through channels independent of the larger aircraft, so there is little point in trying to use the same electric system. Although the 14-volt d-c system seems more likely, 28-volt d-c systems may be used for these airplanes.

Small and Medium-Sized Commercial and Military Aircraft. The advantages of the 120-volt a-c and d-c systems are not so apparent on small and medium-sized aircraft and, in fact, introduce some complications. There is a definite advantage, from a maintenance viewpoint, of standardizing on one voltage for these aircraft, and it seems likely that the 28-volt d-c system will be the standard for these airplanes.

Large Transport and Bombing Aircraft. Aircraft will continue to increase in size and carrying capacity. It seems safe to predict that these large aircraft will use electric systems operating at potentials of at least 120 volts. Less obvious is the choice between a-c and d-c systems, as this choice depends to a very large extent on the development work which will be done on these two systems within the next few years.

It seems likely that electric systems will supersede to a large degree other forms of auxiliary power in aircraft. The advantages become much more apparent when higher transmission voltages are used.

The possibilities in the use of electricity on aircraft are limited only by the limits of man's imagination. The classic idea, which still stirs the engineering imagination, is the prediction that electricity will be used to transmit power from engines to the propellers, much in the fashion of the modern Diesel-electric locomotive.

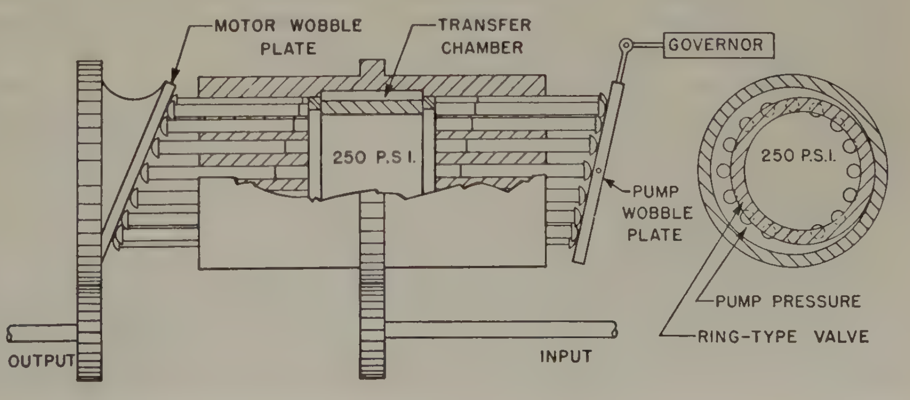
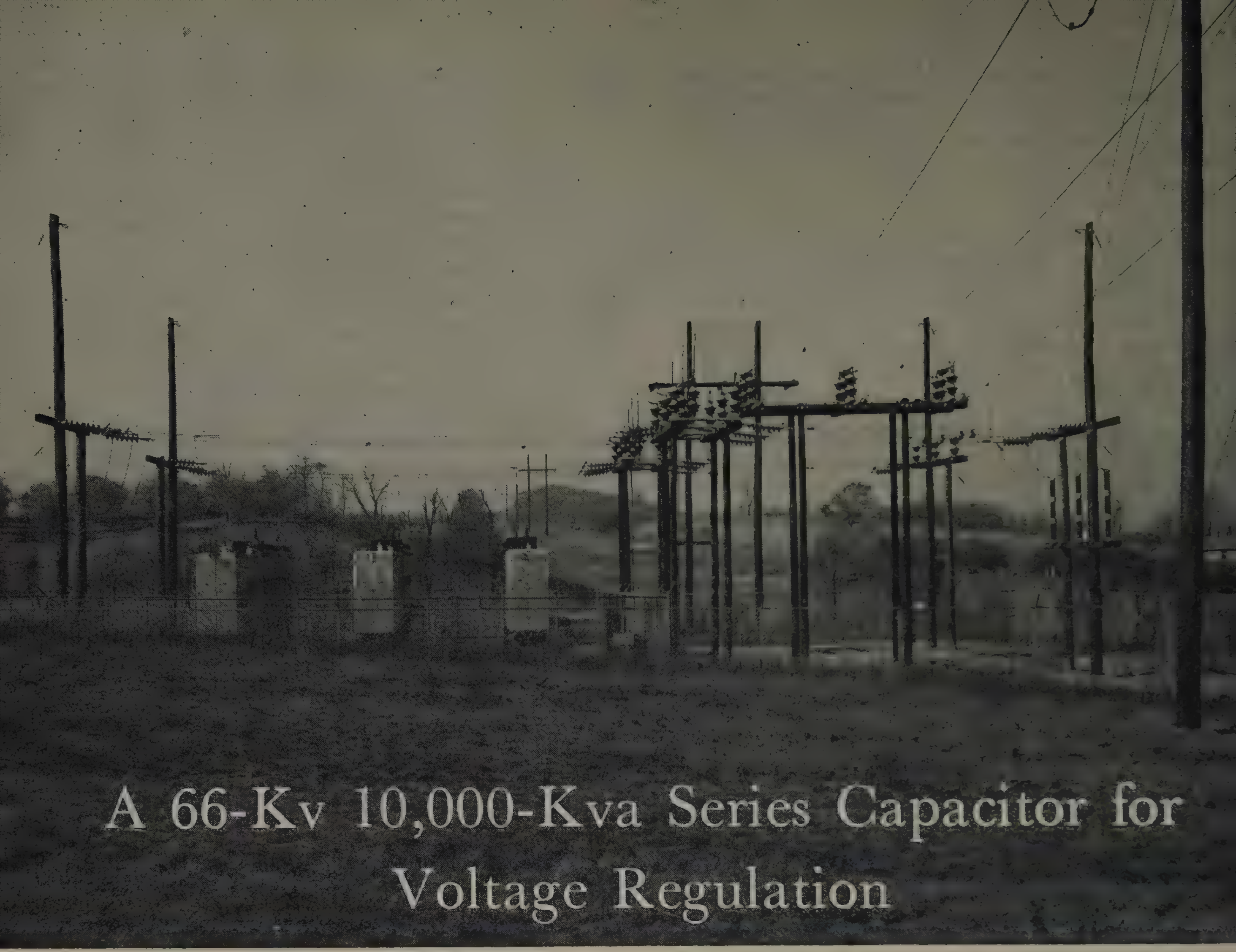


Figure 2. Principle of constant-speed drive



A 66-Kv 10,000-Kva Series Capacitor for Voltage Regulation

Light flicker and voltage regulation resulting from an intermittent arc furnace load have been corrected by the largest series capacitor in existence. The design, installation, and protection of this unit presents interesting and unique problems.

AT Kennedy substation, in October 1947, the largest series capacitor installation in existence, and the first to be installed at 66 kv, was placed in commercial operation by the Duquesne Light Company, Pittsburgh, Pa. The substation is installed in the Phillips–Crucible 66-kv transmission line, 14 miles in length. This line is of modern wood pole construction and was installed in 1940 to serve a large steel plant. The initial load was about 10,000 kva, and since has increased to approximately 40,000 kva. Electric arc furnaces are the principal load. Other major load consists of large synchronous motor generator sets and a 4,000-horsepower wound rotor motor.

Until recently the only load on this line was that of the steel plant; however, this year a tap was connected to provide 10,000-kva service for the town of Midland, Pa. This increased load, plus a large proposed extension of the steel plant, made it imperative that some action be taken to improve voltage regulation and alleviate annoying voltage flicker produced by the electric arc furnaces. The flicker also affected the stable operation of the synchronous motor generator sets. The Crucible 15-minute billing load is 28,000 kw at 87.5 per cent power factor, or 32,000 kva. The instantaneous load is 28,600 kw at 78.3 per cent power factor, or 36,500 kva.

The Crucible instantaneous peak load of 28,600 kw

Based upon three papers: **48-55,** "A 10,000-Kva Series Capacitor Improves Voltage on 66-Kv Line Supplying Large Electric Furnace Load," by B. M. Jones, J. M. Arthur, C. M. Stearns, and A. A. Johnson; **48-56,** "Design and Layout of 66-Kv 10,000-Kva Series Capacitor Substation," by G. B. Miller; and **48-57,** "Design and Protection of 10,000-Kva Series Capacitor for 66-Kv Transmission Line," by A. A. Johnson, R. E. Marbury, and J. M. Arthur. The papers were presented at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948, and are scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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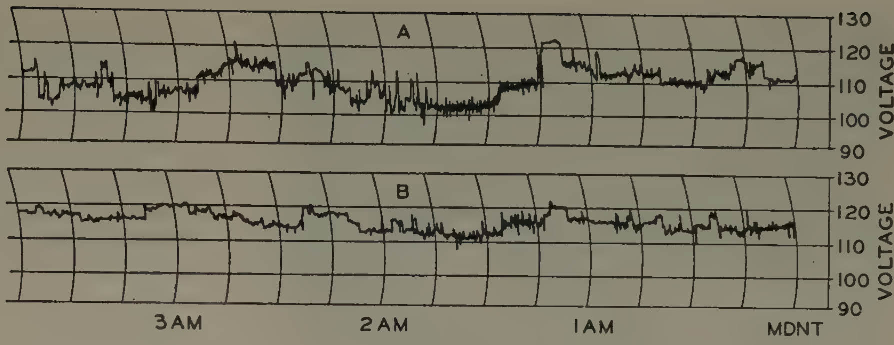
Figure 1. Crucible 11-kv voltage charts with heavy furnace load
A—Before series capacitor installation
B—After series capacitor installation



at 78.3 per cent power factor caused Crucible voltage to drop from the no load value of 11,900 volts to 9,800 volts. Occasionally, the Crucible voltage ranged from 12,100 volts at no load to 9,800 volts at full load. Figure 1*A* shows 11-kv voltage at Crucible before the series capacitor was installed there.

In addition to the excessive regulation, the furnace loads fluctuate so rapidly that they cause severe instantaneous voltage drops or voltage fluctuations on the 11-kv bus and 66-kv bus at Crucible, and poor voltage regulation and less severe voltage fluctuations at other points along the 66-kv line.

After consideration of various methods of improving voltage regulation (step-type motor voltage regulator, synchronous condenser, switched shunt capacitors, and a second 66-kv line), a series capacitor was selected because it fundamentally is suited to reducing flicker and improving voltage, doing both efficiently and at relatively low cost. It is inherently automatic in operation, because it introduces a voltage which leads the current 90 degrees and is directly proportional to the magnitude of current. The capacitive reactance voltage instantaneously compensates for a like amount of line inductive reactance voltage for all values of the current, alleviating rapid voltage fluctuations and reducing voltage drop.

Because a series capacitor reduces the impedance of a line, it increases, in effect, the capacity of the line by increasing utilization voltage. With the 10,000-kva series capacitor in the Phillips–Crucible line, current values are reduced ten per cent for the same delivered kilovolt-amperes.

If the Crucible load increases and a second line from Phillips to Crucible required to carry the line amperes, the series capacitor also will be needed and can be used advantageously. This can be done by carrying the second line through the capacitor and increasing the thermal rating and reducing the ohmic value of the capacitor.

SELECTION OF CAPACITOR

The proper size of a series capacitor depends in general on:

1. The maximum ampere load of the circuit, giving consideration to possible growth.
2. Amount of voltage improvement desired.
3. The ohms reactance of the line and transformer banks involved.

Although the present ampere load at Crucible is less than the 500-ampere rating of the 66-kv line, it is expected that the load will grow. Therefore, the rating of the capacitor was selected as 500 amperes.

Calculations indicated that the inductive reactance from Phillips power station to the Crucible 11-kv bus must be reduced approximately 14 ohms to raise the minimum voltage to 110 volts with loads of about 30,000 kw at around 80-per-cent power factor. A capacitive reactance of 14 ohms would compensate for the reactance of the Phillips–Crucible line of 11.49 ohms plus most of the system reactance at the Phillips bus of 3.59 ohms. A 14-ohm series capacitor on a circuit carrying 500 amperes has a voltage drop across the capacitor of 7,000 volts per line. As 7,000-volt capacitors do not exist, or at least are not standard capacitors, three 2,400-volt 15-kva capacitors in series were selected.

Capacitors of 2,400 volts allow the use of standard protective devices, such as protective gaps and by-pass switches. The 2,400-volt capacitors also will be useful elsewhere on the Duquesne Light System should the capacitor installation ever be abandoned.

After the 2,400-volt 15-kva unit capacitor was decided upon, the total number of units was determined by using the rated ampere values of each unit, namely 6.25 amperes. As the series capacitor must have a 500-ampere rating, 80 units were provided in parallel. The nominal impedance of each unit is 384 ohms, and the total impedance of 80 such units in parallel would be 4.8 ohms, or 14.4 ohms for three groups in series.

Standard 15-kva capacitor units have a guaranteed tolerance in rating of minus 0 per cent and up to plus 13 per cent. This means that the impedance of each 15-kva unit may vary between 384 ohms and 340 ohms. Assuming an average distribution of 362 ohms, the total capacitor impedance is approximately 13.5 ohms.

Calculations indicate that with a 500-ampere 13.5-

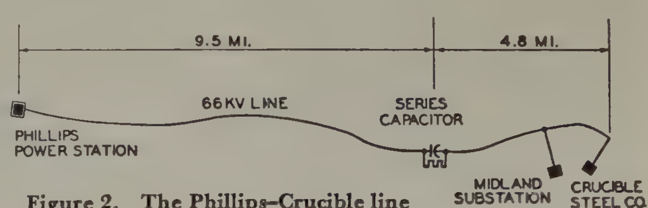


Figure 2. The Phillips–Crucible line

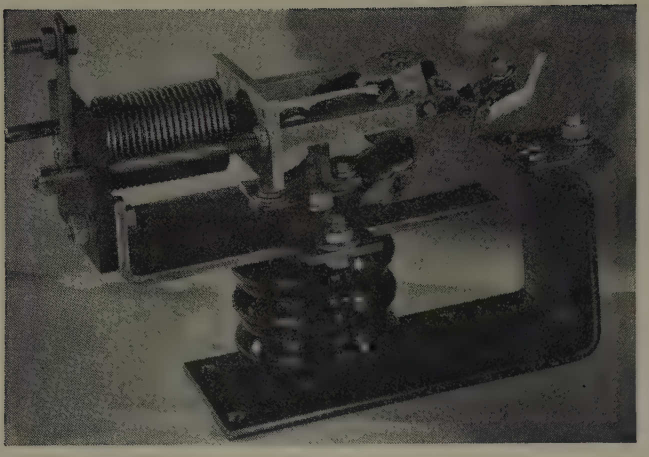


Figure 3. By-pass switch showing the contacts and the operating bellows

ohm series capacitor, the present instantaneous load of 28,600 kw at a power factor of 78.3 per cent would result in a maximum regulation range of 12,100 to 11,050 volts. This was considered satisfactory.

LOCATION OF CAPACITOR

Where load is not distributed along the line, a series capacitor can be placed in general at any location on the supply side of the load. The capacitor should be located so that the maximum fault current on the load side of the capacitor does not exceed the momentary rating of the protective devices. Furthermore, it should be so located that the terminal voltage on the load side does not exceed the voltage of lightning arresters normally used by the power company. Accessibility is an important point in locating the capacitor. Hence, the capacitor installation was made between the Phillips power station and the Midland feeder as shown in Figure 2, 4.8 miles from the customer's end of the transmission line.

PROTECTION

Gaps. A maximum current loading is permitted of 1.5 times rated current or 750 amperes for five minutes to take care of short time overloads. A parallel gap is applied for voltage protection and set above the voltage corresponding to 1.5 times rated current. The parallel gap protection is provided for each of the three groups of 80 capacitor units and limits the voltage which may appear across the series capacitor to approximately double the continuous rating of each group, or about 4,800 volts.

The gap protection consists of a gap designed for low arc drop and is designed in such a manner that arcing can take place without restriking, thus effectively protecting the capacitor if the gap has broken down. The flow of current through the gap also passes through a thermal element which initiates the closing of a switch which by-passes both the gap and the capacitor units, thus limiting the heating of the gap. Once the gap is by-passed by the switch, current ceases to flow through the thermal element and its temperature returns to normal. As the thermal element cools off, the by-pass switch is opened and the series capacitor is restored to service.

By-Pass Switches. By providing a parallel gap for each of the three groups of 2,400-volt capacitors on each phase, a very simple bellows-operated by-pass switch could be applied across each gap as previously mentioned. This scheme is applicable because high speed restoration of the series capacitor to the circuit after a by-pass switch closure is of minor importance, particularly when it is realized that these switches very seldom will be required to operate.

These protective devices have the advantage of requiring no external power source. The advantage of the bellows-operated by-pass switch lies in the fact that the bellows current elements are not inductive and operate over a wide range of current. Where the possible fault current is greater than 2,500 amperes, as in this instance, the bellows is operated by means of a saturating current transformer which limits the current through the bellows to 2,500 amperes for fault currents in the line up to 5,000 amperes. At the low current range, the current through the bellows is stepped up; and in the medium range, the ratio is about one to one. Because each group of 80 capacitor units is protected separately by self-contained protective devices, the protective devices operate independently as required.

A by-pass switch is shown in Figure 3. It contains a toggle mechanism actuated by a special design stainless bellows containing volatile liquid sealed after the removal of air. At all ambient temperatures, the bellows contracts with a force which is able to open the switch when forced into the closed position and released. A current flow through the bellows causes the contraction force to disappear because of vapor pressure which builds up high enough to cause the bellows to expand and close the switch. The closing of the switch terminates the flow of current through the bellows but the switch remains closed until sufficient condensation takes place within the bellows to develop the required contraction force to reopen the switch.

Each group of 80 capacitor units in the series capacitor is protected directly by the parallel gap. The main purpose of the by-pass switch is to limit the duration of the arc within the gap. However, another important purpose of the by-pass switch is to restore the series capacitor to the circuit if the gap should be flashed over as a result of transient voltages of any kind.

Protection Against Overload. Because the normal line current is well within the rated current of 500

amperes and the load currents are under frequent observation by operating personnel, no special provisions were made to by-pass the series capacitor in the event of prolonged overloads.

Failure of an Individual Capacitor Unit. Individual fuses are provided on each capacitor unit which automatically will disconnect a unit that might become short-circuited internally. This type of fuse protection is ample because of the large number of capacitor units in parallel. The operation of one or two fuses will have little effect on either the voltage on the capacitors or the total reactance of the entire installation.

Protection Against Resonance. The possibility of subsynchronous resonance under certain conditions of load and motor starting is well known in connection with series capacitors. Lightly loaded synchronous motor hunting may be aggravated by the presence of a series capacitor. Self-excitation of induction motors also may result. Ferroresonance of transformers is another source of undesirable subharmonic currents. It is, therefore, common practice to stabilize series capacitors by placing in parallel with them a resistor unit of suitable ohms. The effect of the parallel resistor is either to prevent or damp out subsynchronous resonance associated with motor startingand magnetizing current on power transformer banks. It also damps resonance at any frequency.

Each phase of the series capacitor is shunted by a resistor which may be set for several values of ohms between 100 and 400 ohms. The resistor unit has a thermal rating for continuous operation at any resistance value.

The resistor assembly for each phase consists of four 400-ohm resistors designed for continuous operation across 7,200 volts. The connections are arranged so that one 400-ohm resistor may be operated alone or two, three, or all four may be operated in parallel. Thus, 400, 200, 133, or 100 ohms may be obtained by proper connections. When the optimum resistance is determined, a permanent single-value resistor probably will be installed.

Each 400-ohm resistor consists of 72 edge-wound nickel chrome steel resistor units. Each unit is

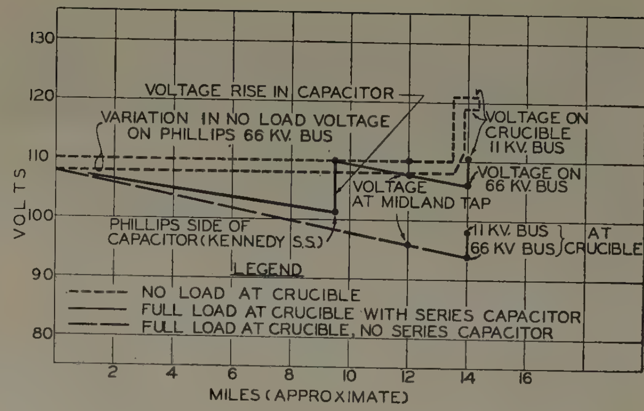


Figure 4. Voltage diagram showing regulation on Phillips-Crucible 66-kv line and Crucible 11-kv bus before and after series capacitor installation

wound around a refractory insulator which is reinforced by a stainless steel supporting bar. The units are mounted from each end on zircon (high temperature) procelains, between two angles, with a 7,500-volt insulator on both ends of each angle.

LAYOUT OF INSTALLATION

The substation is located on 1.4 acres of gently sloping farm land, adjacent to an improved highway. The site lies directly under the transmission line.

The outdoor series capacitor equipment consists of the capacitor compartments together with a protective device compartment assembled on a structural steel

Figure 5. Side view of equipment

The capacitor and output switch are on the left, the resistor and input switch on the right, and the by-pass switch in the center

base and covered with a formed sheet steel roof with provision for roof entrance bushings. Flexible braided connectors and horizontal and vertical bus bars are used for making connections between capacitors, protective devices, and roof entrance bushings.

The series capacitor phase units are located on 15-foot centers. The concrete foundation slabs supporting them have no piers or footers below the frost line. These slabs are at ground surface elevation and set on nine inches of crushed slag. This construction allows for expansion of the ground when freezing and will permit seasonal movement of the equipment. This, however, is not considered to be objectionable as each phase unit is entirely independent of the others and free to move.

The capacitor compartments and the protective device compartments, including the doors, are constructed of structural steel angles and formed sections of one-eighth inch thick steel welded together to form a rigid and self-supporting structure. The doors have concealed hinges and are provided on each side of the housing to permit ready access to the capacitor units and the individual capacitor fuses. The capacitor compartments have three shelves each arranged for supporting two rows of indoor capacitor units. The bottom of each capacitor compartment is covered with perforated sheet steel, and the side walls near the roof have screened ventilators to provide adequate ventilation. Figure 1 shows the complete series capacitor housing for one phase ready for installation.

Each housing containing 240 capacitor units is supported on eight 69-kv post-type insulators. One insulated roof bushing provides for the 7,200-volt insulation while the housing forms the other terminal. The insulation to ground for the housing and all of the series capacitor units is provided by the 69-kv insulators between the housing and ground.

A grounding switch is provided for short-circuiting the series capacitor and grounding it so as to protect the operator from charges on the capacitor and accumulated static charges on the housing. This grounding switch is interlocked with the main by-pass and the isolating disconnecting switches.

The three protective devices which include the gap and the by-pass switches for the three groups of 80 capacitors per phase are placed in the front of the housing and supported on 7,500-volt insulators. The housing for each phase is the same.

The resistor units for each phase are assembled in a housing 20 feet long, $7^1/_2$ feet high, and 38 inches wide. The construction is such that excellent radiating characteristics are secured, thus eliminating localized heating.

An attempt was made in the design of the grounding grid to limit the ground resistance to approximately one ohm. Sample ground resistance readings, taken at the

Figure 6

A—Interior view of capacitor housing *B—Interior view of resistor housing*

beginning of construction, indicated that a grounding grid constructed of a reasonable number of ground rods probably would develop a resistance of 2.3 ohms. The resistance of the transmission line grounding grid taken on the same day was also 2.3 ohms. The two grounding grids were tied together to produce low ground resistance. It was expected that 1.15 ohms would be produced by the combination. Actually, the resistance obtained was 0.65 ohm and somewhat better than anticipated. This reading was taken during wet weather. Dry season conditions probably will give a higher resistance; however, it is expected the value will not exceed the 1-ohm figure.

STATION IMPULSE LEVEL

The 66-kv transmission line being of wood construction, with insulated wood guys and grounded overhead shielding wires, has impulse insulation far in excess of the station equipment insulation. To protect the station equipment from impulses or surges entering the station, both lightning arresters and control gaps have been installed. In addition, overhead shielding wires have been installed over the equipment area and tied into the transmission line shielding wires.

SWITCHING EQUIPMENT

The 66-kv switching equipment required for placing the equipment into or taking it out of service consists of three 3-pole 600-ampere 69-kv air break disconnecting switches.

Extensive tests demonstrated that air break switches are adequate to break charging currents of a capacitor bank of this size. Therefore, a considerable amount of investment was saved by not having to install a circuit breaker in the by-pass switch position.

The Hysteresis Motor

HERBERT C. ROTERS
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New design concept permits economical hysteresis fractional-horsepower motors which are comparable in size and efficiency to the more common induction motor. The smallest of this type, only one inch in outside stator diameter, is reputed to be the smallest a-c synchronous motor built in the United States.

THE HYSTERESIS motor, as a practical type of power motor, is virtually unknown. As a scientific curiosity and as an unloaded synchronous motor it has been known and used for many years. Almost all prior art applications have been confined to driving clocks or other timing instruments. The synchronous clock motor develops an inappreciable power output, of the order of from 5 to 10 milliwatts output, although the input runs from 2 to 3 watts. However, recently developmental models of the hysteresis motor have been built with an output of one-quarter horsepower and an efficiency of 80 per cent. The advances in the art primarily responsible for this improvement are the development of a method of eliminating spurious hysteresis loss in the rotor of the motor and the development of a method of reducing the exciting current. The effect of the elimination of parasitic rotor losses, reduction of copper loss, and the improvement in magnetic materials makes the hysteresis synchronous motor comparable in size and efficiency to the ordinary induction motor.

In certain applications when it is feasible to overexcite the rotor momentarily, it is possible to produce a state of permanent magnetization in the rotor such that the required exciting current is reduced greatly, resulting in a further diminution of the copper loss.

Another important feature of this type of synchronous motor is the absence of transient oscillations of the rotor upon the removal or sudden application of load. Effective damping is produced by the hysteresis loss associated with the oscillation.

Essential substance of paper 47-218, "The Hysteresis Motor—Advances Which Permit Economical Fractional-Horsepower Ratings," presented at the AIEE Middle Eastern District meeting, Dayton, Ohio, September 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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METHODS OF ANALYSIS

An ideal magnetic field distribution in a hysteresis motor is one that will cause no undulation of rotor flux density; that is, when slipping behind the revolving field the flux density at any point in the rotor must follow a major hysteresis loop continuously with no momentary recessions in flux density which would give rise to minor loops. Likewise, when running at synchronism in a steady state, the flux density of any point in the rotor must remain constant. This condition will be realized if the vector distribution of magnetomotive force from the stator is absolutely invariant, revolving as a whole at constant angular velocity, and if, in addition, the rotor turns at constant angular velocity in synchronism with the field. From calculations based upon this idealized field, the actual power converted by means of the hysteresis loop will be

$$P = 4.44 f B \frac{H_s \sin\alpha}{\sqrt{2}} \text{ watts per cubic inch}$$

Disregarding any effects of eddy currents in the rotor this is the maximum torque which just can be brought into synchronism. When the rotor is slipping the axis of magnetization of the rotor will remain at a constant position with respect to the stator field, lagging by the angle α, but will be slipping with respect to the rotor; when synchronism just has been reached the rotor axis of magnetization will become stationary with respect to the rotor but will continue to lag the stator axis by α.

When the torque load is removed from the rotor the angle α will close and the rotor will advance in phase until the axis of rotor magnetization coincides with that of the stator where the mechanical torque is zero. If the rotor is advanced beyond this position by the application of a driving torque the machine, of course, will become a generator. It is obvious that during this process the component of voltage induced in the stator will shift its phase angle from a power absorbing component at full motor torque to a generating component when the rotor is driven.

However, whenever the rotor is allowed to change its phase, as for instance, from the full load position with a hysteresis lag angle of α to the no load position, the magnetization of the rotor will be changed. Thus, if it is loaded after having been allowed to run at no load, it will carry more load before it pulls out of synchronism than it was previously able just to synchronize. This is understandable because at no load the rotor axis of magnetization is oriented fully to that of the stator and hence is more fully magnetized than when slipping. It is for this reason that accurate quantitative results must be predicated upon a known state of magnetization. Such a state is most easily obtainable when the rotor is slipping.

Another method of analysis is based upon the energy concept of the hysteresis loop. The flux density–magnetic intensity relationship in each particle of rotor steel is described by a magnetic hysteresis loop, the various hysteresis loops for the various particles being identical except that they are displaced in phase corresponding to the electrical angular position of the particles. Each particle will go through a complete magnetic cycle for each pair of poles it slips by, and heat energy equal to area of the hysteresis loop for the particle will be released. This energy loss in the rotor is transmitted from the stator through the agency of a magnetic field as a torque times the speed of the field. From this analysis the hysteresis power developed in the rotor will be

$$P = fV \int_{B=0}^{B=0} H\,dB \text{ watts}$$

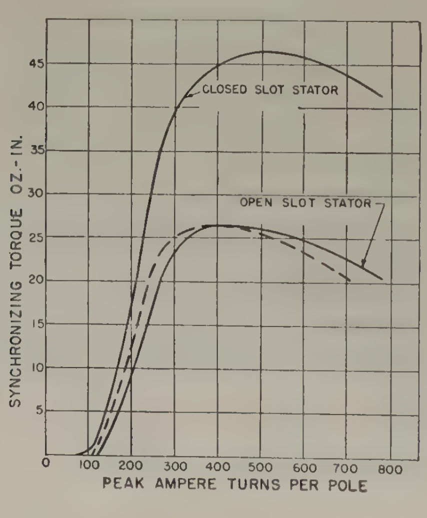


Figure 1. Synchronizing torque as affected by slot openings

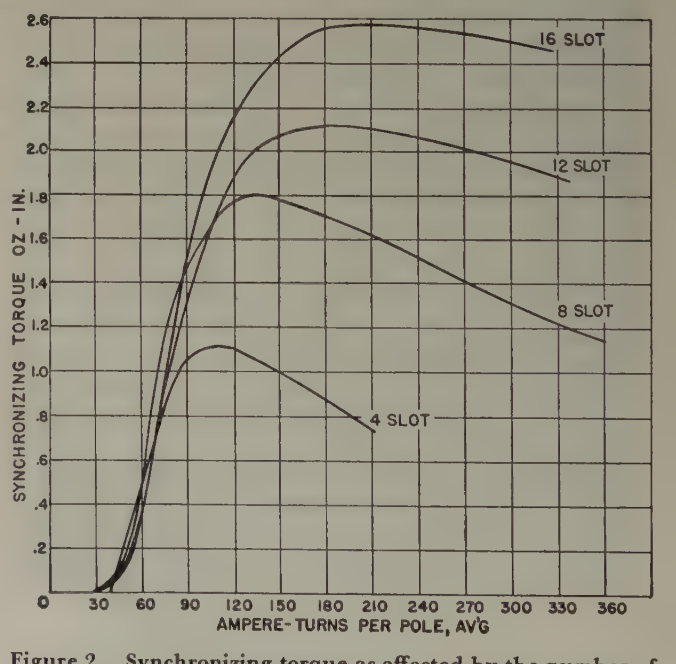


Figure 2. Synchronizing torque as affected by the number of slots per pair of poles

and the torque developed will be

$$T=\frac{fV\int HdB}{2\pi n}\text{ joules per radian}$$

$$=\frac{22.6\,fVW_h}{n}\text{ inch-ounces}$$

where

W_h = area of hysteresis loop in joules per cubic inch per cycle
V = volume of rotor in cubic inches
n = rotational speed of stator field in revolutions per second

EFFECT OF STATOR SLOT CONSTRUCTION

The most important factor in causing the synchronizing torque of a hysteresis motor to deviate from the ideal is the effect of open stator slots. These cause violent fluctuations in rotor flux density as the rotor passes from the short air gap under the solid tooth face to the relatively long and open gap under the slot opening, resulting in the production of minor hysteresis loops superposed on the major loop. As these minor loops represent heat loss in the rotor, the energy for which is obtained as a mechanical drag on the rotor, they properly may be referred to as parasitic loops and the consequent loss as parasitic loss. This loss was previously so large in hysteresis motors that it presented a design limitation.

In some instances, where the slot openings are relatively wide and the air gap short, the minor loops can reach such proportions that their total area exceeds that of the major loop. When this occurs, the rotor will slip below synchronism. Equilibrium below synchronism is usually possible with a solid rotor because of the increase in torque produced by eddy currents in the rotor. Therefore, it has been the conventional practice deliberately to make the air gap between the stator and the rotor large so that the field between the slot openings is more uniform, thus minimizing the field distortion at the surface of the rotor to the extent where synchronous operation is possible, although this practice requires increased magnetizing current and results in increased copper losses and reduced efficiency.

The parasitic hysteresis loss caused by open slots almost can be eliminated, or at least greatly minimized, if closed slot construction is resorted to. In conventional

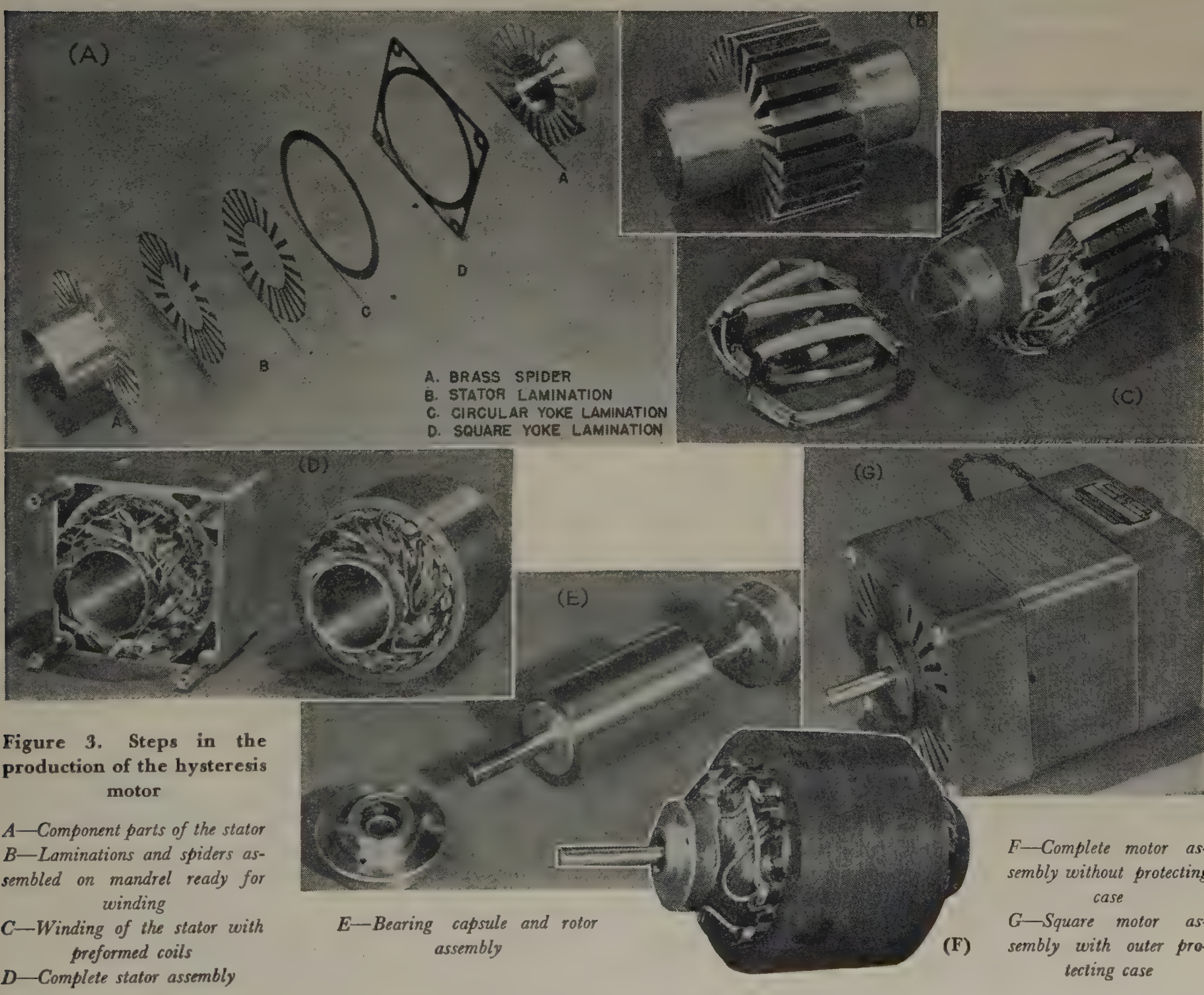


Figure 3. Steps in the production of the hysteresis motor

A—Component parts of the stator
B—Laminations and spiders assembled on mandrel ready for winding
C—Winding of the stator with preformed coils
D—Complete stator assembly
E—Bearing capsule and rotor assembly
F—Complete motor assembly without protecting case
G—Square motor assembly with outer protecting case

induction and synchronous motors, closed slots would be considered very detrimental to the characteristics because of the resulting reduction in power factor and output caused by shunting the flux away from the rotor. However, in the hysteresis motor, closing the slots produces advantages which far outweigh the afore-mentioned disadvantages. The effect of the closed slots will be greatly to reduce the dips in instantaneous rotor flux density in the intertooth space.

Figure 1 shows the difference in performance of otherwise identical motors. Part of the increase in torque results from the fact that with bridged slot construction the same magnetomotive force produces a greater flux because of the lower reluctance of the air gap between the stator and rotor. However, the increase in torque from this factor is a small part of the total improvement in synchronous torque.

The number of slots per pair of poles and the distribution of the coils in these slots determines the wave form of the stator magnetomotive force. As the number of slots is increased the wave form is improved, approaching a sine wave more closely. However, as the wave advances it will undulate in magnitude, causing the magnetomotive force effective under a given region of the wave to vary up and down about an average value. The extent of these fluctuations will depend on the number of slots per pair of poles, decreasing as the number of slots increases. The actual variation in stator magnetomotive force for a 2-phase stator has been calculated from the instantaneous wave forms for a point on the rotor surface as it rotates synchronously with the field. This variation amounts to from 15 to 50 per cent of the average magnetomotive force for 12- and 4-slot stators, respectively. The actual flux density variation is reduced greatly below this figure when closed slots are used because the bridges between the teeth reduce the absolute magnitude of the variations.

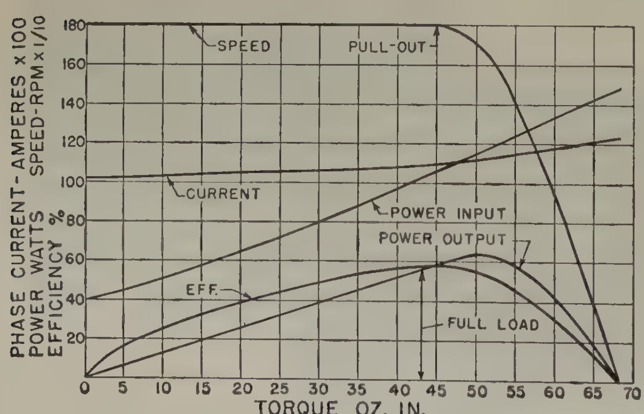
A quantitative analysis of the effect of changing the number of stator slots would be very difficult, if not impossible, when closed slots are used. However, some conclusions can be drawn from carefully correlated experimental work. For this purpose a series of four stators, built to be identical, were prepared. The results of tests are shown in Figure 2.

These data show that the slot bridge of a 4-slot stator will reach saturation when the effective magnetomotive force over the pole face is only approximately 25 per cent of that required in a 16-slot stator to produce saturation. When the slot bridge saturates, it is essentially the same as having an open slot because the saturated bridge has a permeability only a few times that of air. Under these conditions excessive parasitic loss occurs at relatively low excitations. The use of a larger number of slots primarily enhances the effectiveness of the slot bridges because it places several of them in series, allowing them to perform their function of preventing pulsation in rotor flux density to much higher values of total pole magnetomotive force.

PRACTICAL CONSTRUCTION EMBODYING CLOSED SLOTS AND DISTRIBUTED WINDINGS

A practical method of construction of a closed-slot distributively wound motor with a short air gap which retains all the advantages of the closed slots, together with ease of construction, is illustrated in Figure 3. For special synchronous effects the rotor can be modified. A salient pole construction will give a rotor which synchronizes at a fixed phase angle with reference to the supply.

The unique feature of the method of assembly described is that the stator is a unitary structure requiring no external frame for alignment, and the bore of stator and the bore of the brass spiders or bearing holders are aligned automatically to a high degree of concentricity without machining. This alignment is so good that the air gap on the production assembly for a 1.75-inch diameter rotor 3 inches long is only 0.008 inch. Preproduction models have been operated with a 0.003-



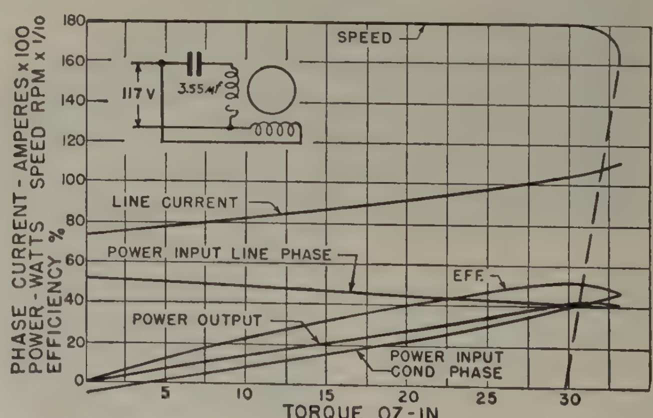


Figure 4. Load characteristics

A—Balanced 2 phase, 130 volts, 60 cycles, 1,800 rpm, 65-degree-centigrade temperature rise, full load

B—Single phase, 117 volts, 60 cycles, 1,800 rpm, 55-dgeree-centigrade temperature rise, full load

inch air gap. The main feature of the alignment obtained by this method of construction is that it depends only upon one concentricity, that of the bearing, assuming, of course, that the rotor is concentric with its own shaft.

A short gap is highly desirable from the performance standpoint as it reduces the required exciting current and hence the copper loss. However, this reduction in copper loss is a net advantage only if the reduction in air gap does not result in an increase in parasitic loss greater than the decrease in copper loss. In the usual motor with open slots the economical minimum air gap is limited by parasitic losses. However, in the construction described with closed slots the parasitic losses are so reduced that the usual limitation in the length of air gap is manufacturing tolerance.

ELECTRICAL DESIGN

The electrical design of a hysteresis stator of the type described is carried out in a manner exactly the same as for the stator of any polyphase synchronous or induction machine. As already indicated, where it is desired to operate at high power levels, special attention should be given to the wave form of stator magnetomotive force. To this end, within mechanical limits, the largest practical number of slots per pair of poles should be chosen.

Short pitched coils are also advantageous as they help improve the wave form while at the same time increasing the ease of winding and decreasing the length of the end connections. The stator slots, of course, should be closed to avoid parasitic losses. The minimum thickness of the bridge rings will be determined by mechanical considerations, and the circumferential length of this minimum section should be made as short as possible; that is, the thickness of the bridge ring should increase rapidly from the minimum.

The initial design of the machine begins with the choice of rotor material. This choice is almost entirely an economic question. Many materials are available, all having different energy levels for the same flux density and requiring different magnetic intensities to develop this flux density. The economic working range of rotor flux density is from about 50 to 80 kilomaxwells per square inch, excluding the Alnicos.

The usual criterion in designing a hysteresis motor is to make the dimensions such that the over-all cost is least, or to make its size a minimum. Efficiency generally is not a requirement, except as it influences the heating, or if the motor is used with a restricted source of power. For a motor with an intermittent rating the greatest economy, both in size and material cost, results if the flux density is held high. The choice of a high versus low energy level steel depends on the cost of the rotor relative to the stator and how high the excitation can be raised during the period of operation. For machines operating for very short times a minimum of size can be achieved by using one of the higher energy level steels operating at a high density. However, operation at high excitation levels is only practical if the winding is well distributed in many slots.

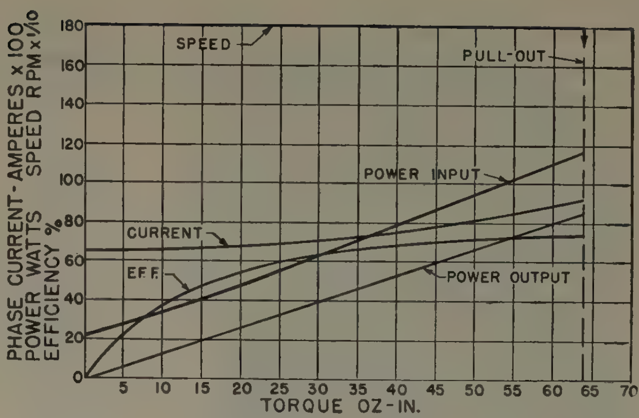


Figure 5. Load characteristics of overmagnetized hysteresis motor

Operating under conditions of Figure 4A except momentarily magnetized at 200 volts

The stator tooth section must be designed to carry the rotor flux plus that of the bridge paths plus the usual leakage. The magnetomotive force that must be developed in the stator must be sufficient to send the flux through the rotor, across the rotor-stator air gap, through the teeth, across the stator tooth to the yoke ring air gap, and finally through the yoke ring. The copper of the stator must be sufficient to develop this magnetomotive force without exceeding a safe temperature rise.

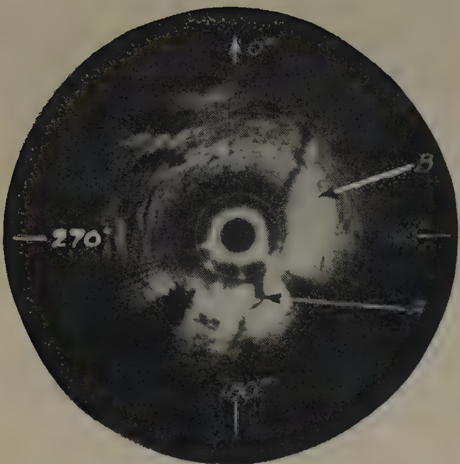
PERFORMANCE

Figure 4 shows typical load characteristics of one of the experimental machines wound for 2-phase and single-phase operation.

The largest element of power loss in the hysteresis motors described is the excitation copper loss. This loss can be decreased greatly if the motor is overexcited momentarily after synchronism is reached. Such overexcitation can be carried out by raising the voltage or current. The benefits obtained from overmagnetization depend upon using the rotor in the same manner as an ordinary permanent magnet is used; that is, the rotor must supply magnetomotive force to its external magnetic circuit. Any condition of operation which tends to weaken the retained magnetism gradually will change the magnetic state of the rotor until it finally assumes those characteristics which it would have had if it hadnever been overmagnetized. Oscillation of the rotor produced by usual causes present in synchronous machines, or load surges, which momentarily change the phase position of the rotor, will cause such demagnetization. Hence, for stable operation in the overmagnetized state it is best if the inertia of the load is low and if the machine is not operated too close to the pull-out point. Typical overmagnetization load characteristics are given in Figure 5.

Air-Borne Radar

R. W. AYER



Equipped with newly designed air-borne radar, an airplane flys approximately 4 miles west of the Hudson River (A), New York, N. Y. The center circle represents the airplane's position. Thin circles are range marks—in this instance 2-mile marks. In the right forward sector the narrow pencil beam is picking up the level terrain near the river (B). In the left forward sector strong echoes and deep shadows indicate something at approximately $8^1/_2$-mile range. The black area of no echo extending outward from the circle of zero range (safety circle) indicates that there are approximately four miles of "clear air space" in front of the pilot.

SEVERAL AIR-LINE accidents during the winter of 1945–46 focused attention on the need for some means of electronically "seeing" obstacles and avoiding them. At this time there was no satisfactory air-borne radar. Working in close conjunction with an air-line industry electronics laboratory, air-line flight engineering personnel held conferences to decide what operating requirements were needed of an air-borne electronic device to provide simple and easily interpretable cockpit presentation of collision information. The standard polar-plotted information available in the *APS-10* radar was selected. The narrow-beam scanning of the *APS-4* was used to confine the energy to essentially a narrow horizontal slit in the plane of flight, spilling a minimum amount of energy downward.

The first successful test flight resulted on March 5, 1946, when a pilot flying "under the hood," was able to pick his way through valleys in the Catskill Mountain region well below the levels of the peaks, using the radar as the sole means of navigation. In April 1946, a series of plan-position-indicator pictures was taken simultaneously with photographs out of the cockpit window.

Six months of operation of a *DC-4* air freighter between Seattle, Wash., and Anchorage, Alaska, resulted in a great deal of data being gathered, some of which have not been correlated. It was found that with the remarkably abundant land–water contrast available along the coast of Alaska, a great deal of navigating could be done with the search phase of the radar, as well as to use it for avoiding mountain peaks, particularly during the letdown into Anchorage. The pilots found that they were able and willing to make blind letdowns with the radar alone, provided, in the event the radar failed, they had a predetermined heading on which to climb out safely. This phase of the collision prevention ability of the radar has yet to be exploited thoroughly. It is believed that only several years of actual line operation will disclose to what extent it can be used for the purpose of making an instrument letdown.

Essential substance of paper **47-233**, "Using Air-borne Radar to Increase Air-Line Safety," presented at the AIEE Middle Eastern District meeting, Dayton, Ohio, September 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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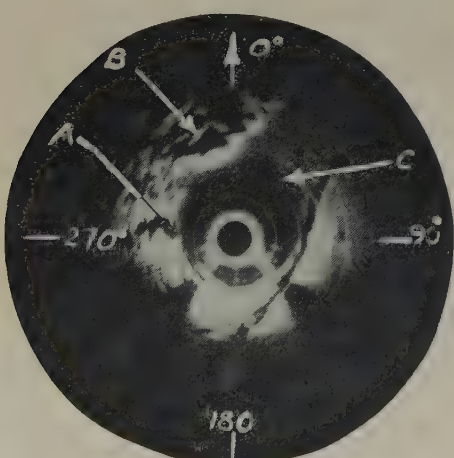
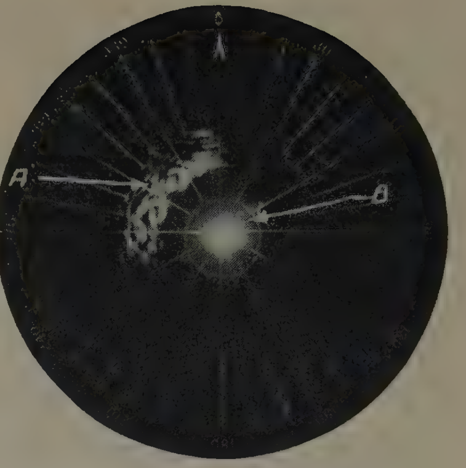


The airplane has advanced four miles on the same heading. The deep shadows previously at 45 degrees have merged with the safety circle, indicating that it is a body of water. Dead ahead at a range of five miles is a strong echo casting a deep shadow beyond it, indicating a collision hazard. At 20 degrees to the right is level terrain toward which the pilot may turn with safety.

Continuing his potential collision course, the pilot has pulled the nose of the airplane up to an attainable climb angle to determine if the radar beam will look over the hill. The picture indicates that he must turn away.

Certainly it can be said at this time that it can be an aid to such a let-down but it does not seem right and proper to consider it as a primary means because of its possible failure.

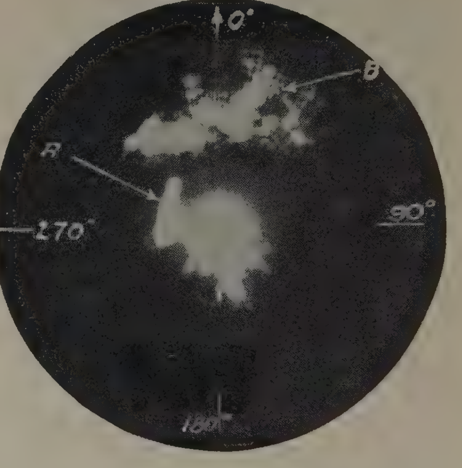


Picture taken with airplane flying in moderate to heavy rain shows terrain echoes through the rain.

STORM WARNING

Long before the air-line investigation of radar began, it was recognized by both the Army and the Navy that air-borne radar had considerable usefulness for detecting storm areas, presumably by reflection from water droplets, and in particular when flying over water because of the elimination of "ground return." However, over land the assurance with which one would pick up the storm echo and distinguish it from the ground echo was very low because of the confusion between the two. The creation of the safety circle through the use of a pencil beam made it possible, when over land and scanning the ground, to see storm echoes that fell inside of the safety circle. Furthermore, by the simple expedient of raising the tilt of the beam so that the scan would be truly horizontal and no longer would see the ground, nothing but storm echoes would be seen.

From the experimental flying, in particular from the *DC-4* service testing in the Alaskan area, it has been found that, in general, the density of the storm echo combined with a knowledge of the outside air temperature (anything below 31 degrees Fahrenheit) can give adequate warning of dangerous ice. It is perhaps fortunate that ice accretion, which normally is not considered dangerous, frequently does not show as an echo at all, or perhaps only as a little fuzz, whereas precipitation from which ice accretion will be rapid and heavy, produces a very strong echo at a considerable range. It is believed that most, if not all, dangerous icing conditions can be avoided with an operable air-borne radar.

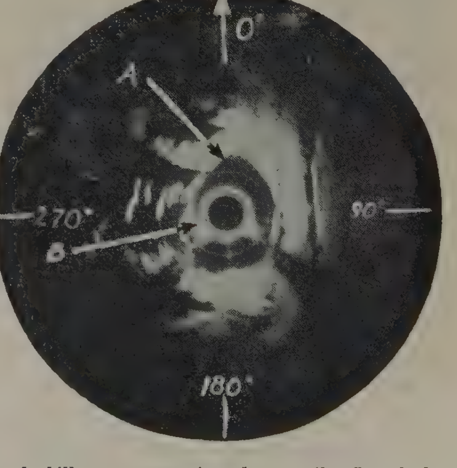


Characteristic picture of well-developed thunderstorm. Note dumbbell shape (A) and ground clutter echoes showing with aircraft in "nose down" attitude (B).

Likewise, dangerous hail which occurs in the Rocky Mountain and Allegheny areas during thunderstorms (sometimes with hailstones as big as baseballs) can be avoided by the use of operable air-borne radar.

Radar can operate to locate obstacles through fairly heavy precipitation, heavy snow, and ice crystals. The service test of the radar has provided considerable evidence that Saint Elmo's fire, northern lights, and severe snow static have no effect whatever upon the operation of the radar. These findings were to be expected from the characteristic of the frequency. It is comforting to know that when all other navigational facilities including very-high-frequency radio are inoperative, some navigational assurance can be obtained from the radar.

(Left) With collision imminent within 35 to 40 seconds, the safety circle is distorted badly.



(Above) As the airplane turns to the right, the hill passes approximately one mile off to the left and the safety circle shows more than three miles of clear air ahead and level ground beyond it. As the airplane banks, the radar antenna is stabilized to maintain the plane of rotation of the pencil beam level with respect to the earth's surface.

AIR-BORNE RADAR WITH X-BAND BEACONS

Much was learned during the war about the precision "homing" possibilities of a responder located on the ground replying to interrogations from an air-borne radar. The air-line flight research has taken up where this left off and developed "beaconry" to a considerable extent.

Known, but perhaps not appreciated, were the possibilities of flying random tracks of the pilot's choosing over only two beacons located on the ground. From the image of two beacons on the oscilloscope, track, position, and heading information are combined in easily digestible form. This information never has been combined before and the present procedure without radar involves the scanning of several instruments to obtain it. It is apparent that en route navigation with radar beacons is basically very easy and precise.

Such extreme simplicity of navigation with its self-checking quality should lend itself to instrument low approaches. Early in June 1946, several beacon arrangements were tried near an airport and it was found possible to line up with the runway with reasonable accuracy, starting the landing approach out of a standard rate 180-degree turn, finishing the turn approximately two miles from the end of the runway. The precision of these approaches, however, was not quite enough to permit descending to much lower than 200 feet and in less than one mile visibility and still not have a drastic maneuver required prior to landing.

Again, the research personnel, after many nights of failure and after trying many beacon arrangements, came up with an idea for a "magnifying glass" to improve the precision, during the last two or three miles, of the approach to the runway. It consisted of sending out one additional pulse from each beacon with the delay on each adjusted so that the second pulses would lie very close to each other in range. Because the delayed pulses always will lie on a radial line from the center of the scope through the initial pulse, the two delayed pulses will show a greater off-course indication when such exists than will the two initial pulses, simply because they are farther out the radius.

GROUND SPEED CHECKS WITH AIR-BORNE RADAR

With the radar, it is possible to pick out any handy target and measure the time that it takes to travel between, say, two range marks on the scope, and from this, immediately determine the ground speed and the drift. The process takes a little over two minutes. If not satisfied with the ground speed, the pilot may change altitude and, in the space of another two minutes, again check his ground speed. Frequently experience has indicated the possibility of picking the optimum altitude, not just a better altitude, within a space of 15 minutes—whereas with the present-day facilities, the optimum altitude most likely never would have been found and the process of finding a better altitude would have taken perhaps hours.

RELIABILITY

The very fact that pulses are sent out by the radar and there is then a "listening period" during which time the echo is received, makes the radar basically closed-circuit and self-checking. Any failure of the radar so far experienced has resulted in either no indication on a plan position indicator, or a completely ununderstandable one. Many attempts have been made to hash up the radar information in an attempt to produce an unidentifiable lie. Only on one occasion has this been successful and this was chargeable in no way to the basic characteristics of radar.

ACCIDENT PREVENTION

In considering the accident record, only the accidents of the scheduled air carrier industry were investigated. Eliminating those upon which there can be any reasonable doubt and taking only those accidents in which it seems perfectly obvious that the pilot must have thought he was either in no danger of colliding with a hill or being destroyed by weather, it still can be said that 11 out of the 31 fatal accidents during 1940–45 could have been prevented had there been an operable air-borne radar aboard. Of the 380 lives lost in these accidents, 160 could have been saved.

The foregoing conclusions are believed to be extremely conservative and it is believed that when the foreign operators, the nonscheduled operators, and the military transport operators are taken into account, the percentage of lives which probably could have been saved by air-borne radar would reach approximately 70 per cent. The round figure which is believed to be safe to assume if the accident record pattern remains approximately the same as it has in the past, is a 50 per cent improvement in terms of lives lost in air transportation if air-borne radar is installed and operating.

A Faster Telemeter for Carrier-Current Channels

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Time-tested basic principles coupled with new frequency techniques, new materials, and refinements in well-known principles have been used to build a new frequency-type telemetering system which combines continuous measurement and fast response with high accuracy and stability of calibration.

TO OVERCOME inherent difficulties in impulse telemeters and to eliminate sources of mechanical maintenance problems, yet without requiring unusual or undesirable types of carrier-current channels, the new frequency-type telemeter was developed. In this system the frequency of the transmitter (modulating) signal varies in proportion to the magnitude of the measured quantity, over the range from 6 to 27 cycles per second. Frequency was chosen as the quantity to be recognized by this system because it is entirely independent of the transmission channel characteristics which are variable in nature. This range in frequency was selected to provide the most desirable balance between fast time of response, minimum carrier band width requirements, and minimum instrument damping. The use of a sinusoidal transmitter signal, instead of the more common square wave impulse signal, permits better utilization of the carrier-current equipment of the type employing audio tone modulation of the carrier. Instantaneous response without overshoot, absence of contacts and relays, and presence of a minimum of moving parts are among the outstanding characteristics of this system.

THE TRANSMITTER

The telewattmeter of Figure 1 will illustrate the principles of the telemeter transmitter. The primary detector is a watt-hour meter of standard construction. It is connected to the circuit to be measured in the usual manner, and produces a shaft rotation at a speed which is proportional to the input watts. (Similar detectors can be used to measure vars, a-c volts, or a-c amperes.)

A voltage whose frequency varies in proportion to the measured quantity is generated by means of a photoelectric pickup actuated by the rotation of the watt-hour meter shaft. A disk having a serrated edge is fastened to the watt-hour meter shaft. Located above the serrated disk is a light source, and below it a photoelectric tube, arranged so that rotation of the disk modulates the light beam directed on the tube. The shape of the serrations is such that a sinusoidal output voltage is obtained from the photoelectric tube. The number of serrations is such that the frequency of the output voltage, with maximum rated input, is approximately 27 cycles per second.

The output of the photoelectric tube is fed directly to a cathode follower, which serves primarily to reduce the output impedance of the pickup mechanism. The cathode follower physically is located close to the photoelectric tube, and, by its use, interference from external electrostatic and electromagnetic fields is made negligible.

The output voltage from the cathode follower is fed to a 2-stage push-pull amplifier of conventional design. The amplifier output is transformer-coupled, thus providing complete electrical isolation. The amplifier also may include and operate an electromechanical relay when required for keying. The voltage and power output of this amplifier are of sufficient magnitude to operate most carrier-current equipments directly.

A "voltage squared" watt-hour meter element using the serrated disk as its driven member is used to provide a finite shaft rotation when the measured quantity has zero magnitude. By this means, a definite distinction is made between "zero input" and "inoperative transmitter," thus providing at the receiving station an indication of transmission outage. This means also is used to provide zero center operation.

A resistor is used to calibrate this constant torque element. Calibration of the transmitter is made by standard watt-hour meter methods.

CARRIER CHANNEL REQUIREMENTS

The transmitter signal is entirely suitable for either amplitude modulation of a fixed audio-frequency tone that modulates the carrier frequency proper, or keying, electronically, a frequency-shift carrier telemeter channel. It is somewhat low for convenient direct amplitude-modulation of carrier frequencies in the 50- to 200-kc band. When keying a frequency shift channel it is

Essential substance of paper 48-46, "A Faster Telemeter for Carrier-Current Channels," presented at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948, and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

E. E. Lynch is a development engineer and **H. C. Thomas** is an engineer in the West Lynn works of the General Electric Company, West Lynn, Mass. **G. S. Lunge** is in the central station engineering division of the General Electric Company, Schenectady, N. Y.

convenient to have one carrier-current frequency transmitted during positive half cycles of the 6- to 27-cycle telemeter frequency, this carrier-current frequency being replaced by a slightly different frequency during the negative half cycles. As the frequency shift is small, a large number of quantities can be telemetered simultaneously over the same route. Frequency-division multiplexing also may be used for telemetering a number of quantities over the same channel.

The output of the amplifier associated with the telemeter transmitter is approximately 30 volts, at all frequencies, when feeding into an impedance of 50,000 ohms. The telemeter receiver requires an input of approximately 15 to 30 volts, across an impedance of 10,000 ohms, from the associated carrier-current receiver. Both the output characteristics of the transmitter and the input characteristics of the receiver are therefore suitable for use with commercial carrier-current equipment.

THE RECEIVER

The receiver is a frequency meter with a linear scale and with a high degree of immunity to response from interfering signals. Its purpose is to receive a frequency signal of from 6 to 27 cycles per second and to furnish a continuous, fast responding output to operate standard indicating, recording, or control initiating devices. As totalizing with the output of other receivers often is required, its reponse must be linear with respect to the input frequency. Most important of all, its response must be consistent; it must have long life stability, comparable to that of the transmitter.

The receiver is shown in simplified functional form in Figure 2. Auxiliary means are required to prepare the signal for the receiver's primary detector. These consist of a coupling transformer, a filter network, a limiting amplifier, and a power amplifier. The primary detector itself is a saturating transformer and rectifier, the secondary output of which has an average value dependent only on the frequency of the input signal. Intermediate means are required to supply power to the electronic components, to furnish a regulated voltage, to provide a biasing current, to provide ambient temperature compensation, and to provide full and light load adjustments.

The output from the saturating transformer, which is a wave of positive and negative pulses, is rectified. The average d-c component is suitable to operate a D'Arsonval instrument to obtain an indication, or a record. To compensate for the 6-cycle signal corresponding to zero quantity, there is generated in the receiver a constant negative current, furnished from a standard-type power supply and voltage regulator. A resistance to adjust this constant current acts as a zero adjustment for the re-

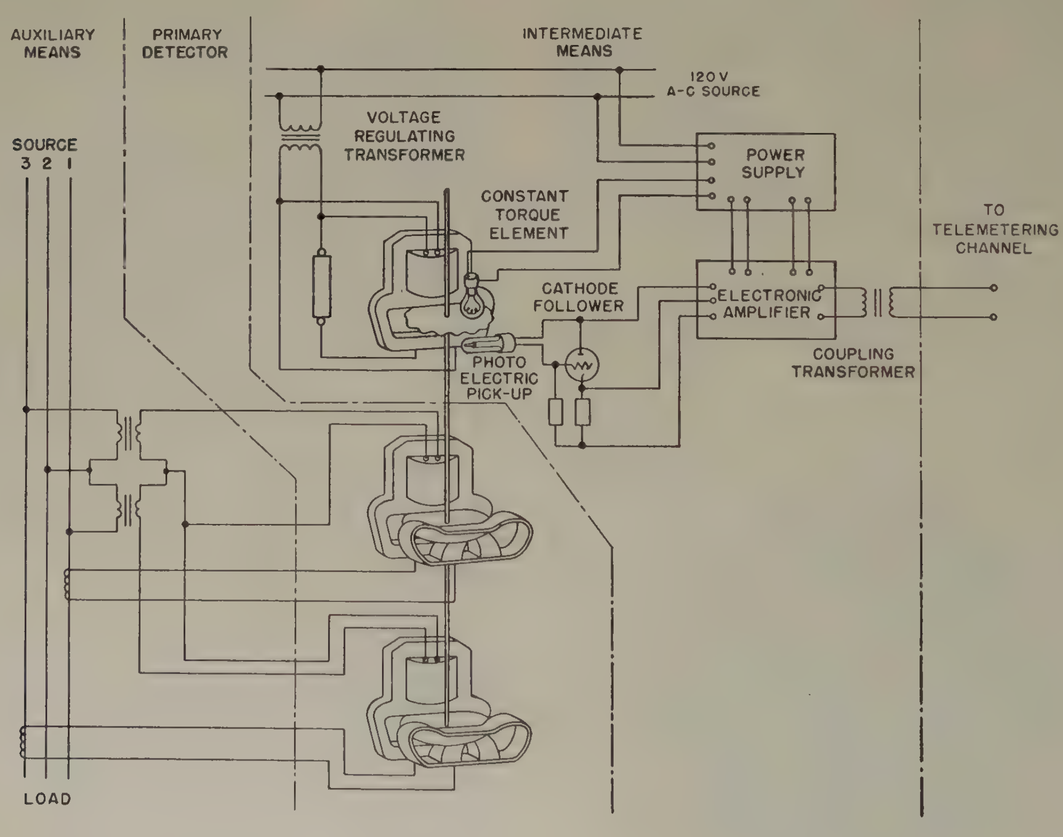
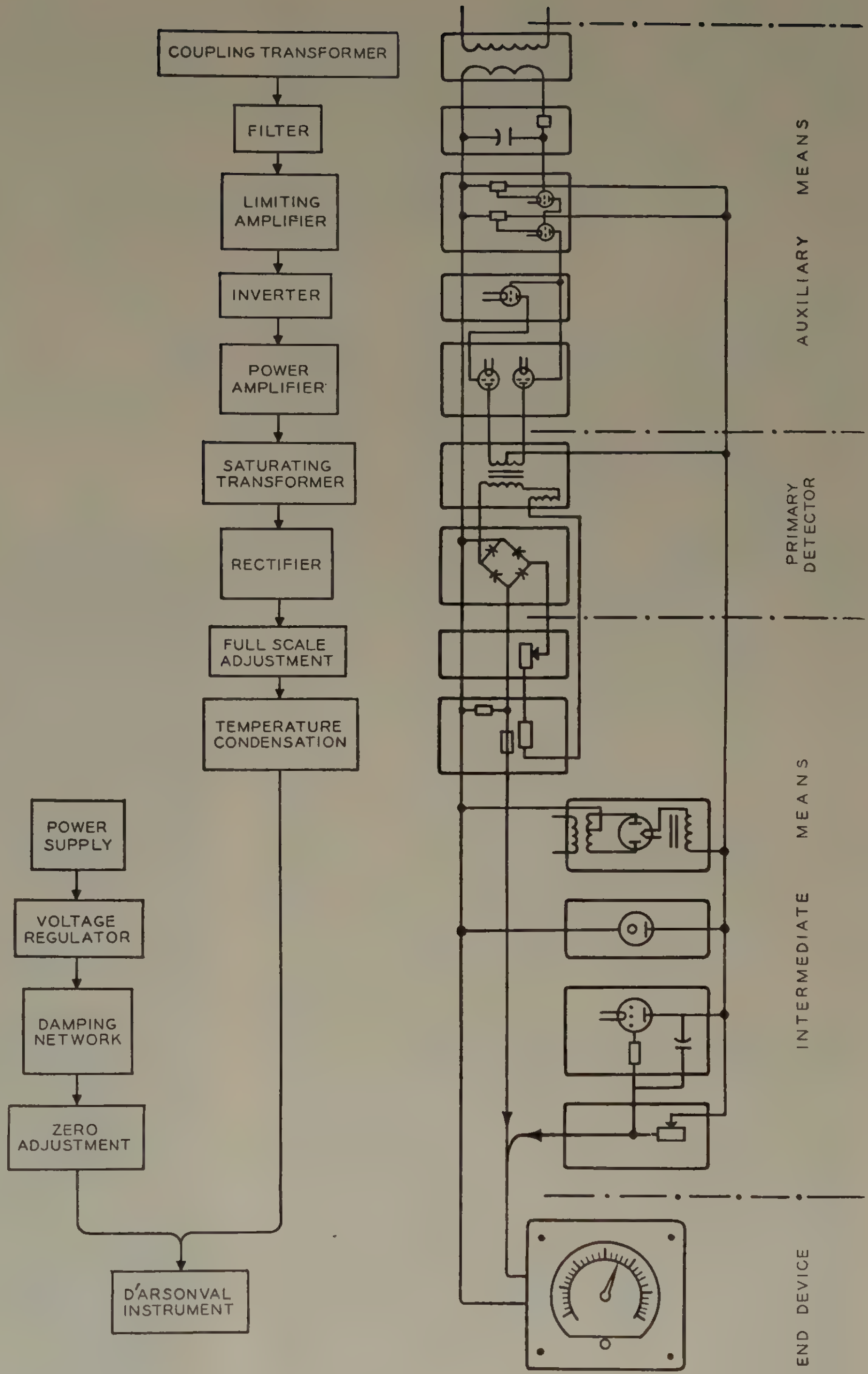


Figure 1. Schematic functional diagram of the frequency-type telemeter transmitter

Figure 2. Schematic functional diagram of the frequency-type telemeter receiver



ceiver. With this arrangement it is possible to distinguish three types of zero reading. The "sub zero" from the constant current indicates receiver operation but no input signal (not even the six cycles). A steady zero indicates the receiver is not operating. A zero reading with a slight 6-cycle vibration indicates that the system is functioning with six cycles (zero magnitude of quantity telemetered for "left zero" scale ranges) being indicated. These features are an aid in checking the equipment after installation, or in case of outage of the carrier channel. In addition, sub-zero readings can be used for special signaling purposes.

An indicating end device is shown in Figure 3; however an indicator, recorder, or both can be used if the proper equivalent load is maintained. These end devices have a full scale rating of one milliampere. Where extreme accuracy is required, accurate end devices may be used. Where less accuracy is needed, lower cost instruments are suitable and useable in the system.

APPLICATIONS

Transmitter. In addition to telemetering values of power, reactive power and alternating voltage or current, auxiliary devices may be used to adapt the transmitter for other applications.

Watts or vars may be totalized at the transmitting end of the channel by converting the paralleled d-c milliampere outputs of torque balance transmitters into proportional single-phase watts by a torque balance converter.

The converter single-phase output is suitable for directly operating a frequency-type telemeter transmitter. This method of totalizing is used when lack of a common source of potential or other considerations preclude paralleling current transformer secondary windings through auxiliary current transformers to operate a single telewattmeter transmitter.

The torque balance converter is also applicable for telemetering d-c milliamperes. The milliamperes might be obtained from a torque balance telemeter channel from a near-by location, for example for forebay water level telemetering.

For telemetering of mechanical position, such as transformer tap position, the position is converted into a proportional alternating voltage for telemetering. This can be done conveniently by a small rheostat or tapped resistor across which regulated alternating voltage is maintained.

Table I. Performance Characteristics of the Telemetering System

This Typical System Consists of a Telewattmeter Transmitter, a Carrier Current Channel, and a Telemeter Receiver. The End Device Is Not Included Because Its Performance Depends Upon the Type Selected. Greater Accuracies Can Be Obtained if it Is Deemed Desirable

Characteristic	Per Cent of Full Scale
Accuracy	1.0
Precision (repeatability)	0.5
Influences	
Voltage (±10 per cent of rated)	1.0
Temperature (±25 degrees centigrade from 25 degrees centigrade)	1.0
Frequency (±0.5 per cent from rated)	1.0
Speed of response	Instantaneous (Less than 1 sec)

When a torque balance converter is used with a frequency-type telewattmeter transmitter for telemetering d-c volts, such as the field volts of a synchronous generator or condenser, or d-c millivolts from a shunt in a d-c circuit, the torque balance converter is built with a d-c voltmeter or millivoltmeter basic element instead of the usual d-c milliammeter element. When the source of direct voltage to be measured must not be called upon to supply any current (in the case of thermal converters, thermocouples, or retransmitting slide wires in telemeter recorders) an electronic high-speed self-balancing potentiometer is used between the direct voltage to be measured and the torque balance converter. This potentiometer provides a d-c milliampere output proportional to the millivolts (or even microvolts) input.

Receiver. When it is necessary to totalize several frequency-type telemeter readings, and simultaneously provide individual readings and subtotals, or when it is necessary to employ an individual telemeter receiver output for automatic control purposes, it is advisable to use the torque balance telemeter retransmitter. By this means the desired milliampere range is obtained with negligible additional time lag. The use of such a retransmitter also makes it possible and convenient to totalize torque balance telemeter readings together with frequency telemeter-type readings. When totalizing with other types of telemeters providing only d-c millivoltages from their receivers, a self-balancing potentiometer will convert such millivoltages to proportional d-c milliamperes that can be totalized with the d-c output of the frequency-type telemeter receivers.

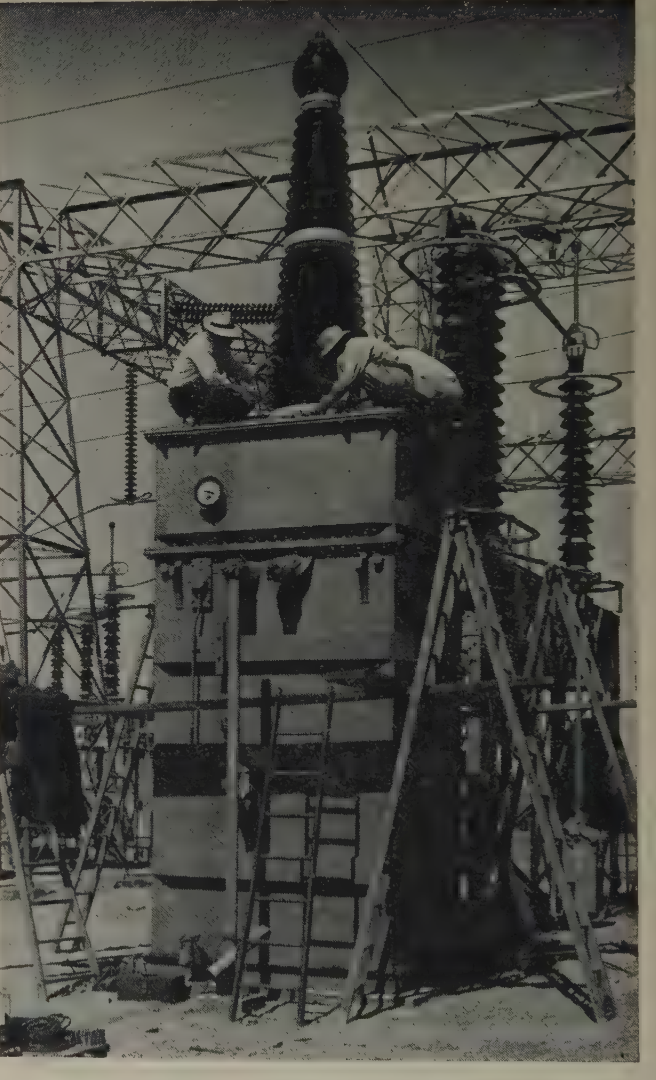
If integration of frequency-type telemeter readings, either individual or totalized, is desired at the receiving point to provide kilowatt-hour or kilowatt demand readings, this readily is accomplished by means of a torque balance converter, the single-phase a-c output of which can operate one or two watt-hour meters (one for each direction of flow, in the case of reversible flow). The watt-hour meters can have kilowatt-hour registers and also, if desired, contact devices to operate any conventional type of block interval demand meters, for one or both directions of energy flow.

A system total or subtotal load, as totalized at the dispatcher's office, also may be telemetered to individual generating stations for their guidance.

In this instance, outage of one or even all telemeter channels need not mean dispensing with the totalized reading, as a manually-set torque balance load injector can be used to replace the missing telemeter reading or readings with approximate exactness.

When large diameter indicating receivers are desired, these may be Selsyn-operated from transmitting Selsyns mounted in the strip chart recording milliammeters, via indication transmitters as torque amplifiers.

High-Voltage Transformers



These two single-phase 300-kva 287,500/4,800-volt distribution transformers are shown being installed at the Silver Lake switching station on the Hoover Dam lines of the Los Angeles Department of Water and Power. They are the highest voltage distribution transformers ever built by General Electric

Suggested Changes in Temperature Limits of Present Standards for Stationary Contact Surfaces

AIEE SUBCOMMITTEE REPORT

With extensive review of tests made during the past 25 years plus the results of certain self-conducted tests as its basis, the AIEE Standards committee subcommittee on conduction in stationary contact surfaces recommends various changes in the present Standards for permissible temperatures on electric contacts. These recommendations, together with pertinent abstracts of present Standards, are presented herewith for the purpose of obtaining comments and criticism.

THE subcommittee on conduction in stationary contact surfaces of the AIEE Standards committee is making a study of the permissible temperature rises that could be allowed on certain electric contact materials when they are applied to relays, contactors, air or oil circuit breakers, knife switches, fuses, bolted joints, or any similar devices. In this study the committee has compiled the present contact temperature standards of the AIEE, National Electrical Manufacturers Association, and the Underwriters' Laboratories. It has reviewed many of the contact tests that have been made during the past quarter century, as well as having some additional tests made by several of the committee members. The members of this committee have been drawn from the major electrical manufacturers, from several of the large power companies, from some of the colleges which are interested in this subject, and from other users and producers. With this background on the subject of electric contacts, the committee recommends for consideration changes in the Standards for permissible temperatures on electric contacts.

Reviewing the present Standards, one is confused not only by the several permissible temperature values that he finds, but by the widely different values. The reason for these variations partly can be explained by the conditions which existed when these rules first were made during 1915 to 1920. During this time copper contacts, and sometimes brass, were the materials that were used almost exclusively. The designers of devices such as contactors, had found that, because these devices were, in general, smaller in current rating and were required to make and break the circuit frequently, they could be operated at higher temperatures than the less frequently operated and larger devices, such as knife switches and circuit breakers. It was found that these more frequently operated devices which had copper contacts could "get by" with higher temperatures than the less frequently operated devices which were larger and were required to carry much higher currents. Therefore, the temperature of the copper contacts under these less favorable conditions had to be much less, and the temperature values that now are found in the Standards were selected and have been in force up to the present.

During the 1920–30 period, tests were made which demonstrated the superiority of silver over copper as a long-time current carrying contact material, and as a result, many of the larger devices which were used for carrying current for protracted periods were changed to incorporate silver or a silver alloy at their contact surfaces.

During the 1930–46 period, both the producers and the users proved to themselves that silver contacts overcome the excess heating difficulties which commonly were experienced with copper contacts. Also, during this period laboratory experiments were made which proved that it is not only safe to run the silver contacts as a higher value than now permitted by the Standards, but that the contact temperature need not be the limiting factor for the rating of the device. A wide variety of test conditions (pressure and current), wherein silver contacts were subjected to 150 degrees centigrade for a number of months, showed that silver was still stable as a contact. Therefore, the maximum limiting temperature that can be used safely must be determined by other factors such as the limiting temperature of insulation in both the solid and liquid forms.

Let us consider whether there are any valid reasons why the permissible contact temperatures should not be increased. Some have claimed that bolted copper-to-copper contacts will oxidize and cause trouble if operated above present permissible temperature values. Extensive tests have been made to ascertain just what does result when a well designed* and properly bolted

* In some instances it may be necessary to use a deoxidizing material at the joint.

Full text of a report compiled by the AIEE subcommittee on conduction in stationary contact surfaces: *chairman*, W. P. Dobson (F '43); *secretary*, W. E. Pakala (M '45).

Stationary contact surfaces refers to all except rotating contacts such as slip rings and commutators.

copper-to-copper contact is heated to 50, 75, 100, and 150 degrees centigrade and held for several months. The results of these tests show that there is no critical change in the current carrying capacity of a high pressure contact at the highest test temperature used.

The class of insulation used near the contacts can be the temperature limiting factor. However, even the use of class *A* insulation will not explain low temperature standards for contacts. For bolted copper contacts, frequently operated copper contacts, and all silver contacts, the maximum permissible operating temperature of the contacts is limited by the insulation and should not exceed 105 degrees centigrade where class *A* insulation is used and the contacts are in air or in oil. (It is not expected that apparatus with contacts immersed in oil will operate at temperatures resulting in oil surface temperatures of 105 degrees centigrade.) For infrequently operated copper contacts the maximum permissible operating temperature is 70 degrees centigrade. This value is determined by the conditions at the contact, and experience and numerous tests indicate that at this temperature contact stability is maintained without opening and closing the contact to remove partially surface oxidation, and so forth.

PERMISSIBLE TEMPERATURE RISES OF CONTACT SURFACES

The temperature values now given in various standards have taken into consideration, at one time or another, such items as design, pressure, maintenance, and years of service. The tests referred to in this report were made in laboratories. Consequently they were of relative short duration compared with the length of experience with various types of contacts. Nevertheless, the tests indicate the possibility of using higher temperatures under certain conditions. Thus, the following values should be considered as objectives towards which many of the present temperature limits may progress as a result of design, maintenance, and experience.

Accordingly, the AIEE subcommittee on conduction in stationary contact surfaces, submits the following grouping of types of contact surfaces and corresponding maximum temperatures, as objectives towards which the art may progress. The permissible temperature rise, when measured as near the contact surfaces as practical, of contact surfaces in switches, fuses, contactors, air and power circuit breakers, terminals, and similar devices, subject to the limitations given under this heading, may be

1. Open-and-close-type contact surfaces.

(*a*). Silver (or approximately equivalent) contacts allow 65 degrees centigrade rise in a 40 degrees centigrade ambient temperature or 50 degrees centigrade rise in a 5 degrees centigrade ambient temperature for a maximum of 105 degrees centigrade.

(*b*). Frequently operated† copper contacts (except laminated copper contacts) allow same temperatures as for silver in the foregoing.

(*c*). Infrequently operated† copper contacts (and laminated copper contacts) allow 30 degrees centigrade rise in a 40 degrees centigrade ambient temperature for a maximum of 70 degrees centigrade.

2. Fixed-type contact surfaces, such as bus joints and terminals.

(*a*). Silver (or approximately equivalent) contact surfaces allow 65 degrees centigrade rise in a 40 degrees centigrade ambient temperature or 50 degrees centigrade rise in a 55 degrees centigrade ambient temperature for a maximum of 105 degrees centigrade.

(*b*). Copper contact surfaces allow 55 degrees centigrade rise in a 40 degrees centigrade ambient temperature or 40 degrees centigrade rise in a 55 degrees centigrade ambient temperature for a maximum of 95 degrees centigrade. (This addition gives values for copper which are 10 degrees centigrade below those for silver. Although copper joints can be made which could operate satisfactorily at 105 degrees centigrade, considerably more care is necessary in making copper joints than silver joints, and it is believed that more data and experience, including maintenance, are necessary.)

† "Frequently operated" implies contact operation at least once in each eight hours that the contact carries current; "infrequently operated" implies less frequent operation.

Table I. Temperature Limits in Existing Standards

All Values Are Rises in Degrees Centigrade Unless Otherwise Indicated

Apparatus	AIEE Standards	NEMA Standards	Underwriters' Standards
Industrial control apparatus:			
Laminated contacts	50	50	50
Solid contacts	65	65	65
Busses, connecting straps, and terminals	50		
Railway control apparatus:			
Laminated contacts	50		
Solid contacts	75		
Power circuit breakers:			
Contacts in air	30*	30	
Contacts in oil	30	30	
Air circuit breakers:			
Contacts	30*		65 maximum temperature
Terminals		30	
Terminals—thermal circuit breakers		40	
Air switches and bus supports	30*	30	30
Relays directly associated with power switchgear:			
Contacts	50		
Fuses below 600 volts, rise above (18 degrees centigrade to 32 degrees centigrade ambient temperature):			
0–100 amperes			50
101–200 amperes			60
201–400 amperes			65
401–600 amperes			75
Fuses above 600 volts:			
Conducting parts except element	30	30	
Exception—railway service	50		
Service circuit breakers:			
Contacts—copper			65 maximum temperature
Knife switches—contacts			30
Enclosed switches			30
Snap switches—contacts			30
Pressure wire connectors		20** and 25	20** and 25
Switchgear assemblies			
Open switchgear:			
Busses and connections	30	30	
Enclosed switchgear:			
(*a*). Temperature rise of air inside enclosure over outside	15	15	
(*b*). Temperature of busses and connections over outside air with busses and connections not brazed, welded, silver-soldered, or silver-surfaced	30	30	
(*c*). Temperature of busses and connections over inside air with busses and connections brazed, welded, silver-soldered, or silver-surfaced	30	30	
NEMA panelboard and distribution board section		30 and 40***	

* Attention is called to the inherent decrease in current that can be carried by contacts in air as a result of oxidation of the contact surfaces. The rating of circuit breakers, therefore, is based on sufficient maintenance to keep the temperature rise within the specified limits.

** Sizes 20 to 000 inclusive allow 20 degrees centigrade rise. Sizes 0000 to 2,000,000 allow 25 degrees centigrade rise.

*** Refer NEMA Standards Bulletin, panelboard and distribution board section (page 4—1/4/43)—maximum total temperature of 80 degrees centigrade. This is an exception—may be used for extended system and high pressure contact.

The foregoing recommendations are based on the following limitations and assumptions:

1. The temperatures are those of the contact surfaces only.

2. The recommendations apply to contact surfaces in air or in oil.

3. The recommended values are based on typical applications and service conditions are subject to modification to meet particular situations and, in some instances, where service and maintenance conditions are favorable, the values for silver may be raised safely. In other instances it may not be possible to obtain the permissible contact temperatures without exceeding the permissible temperature for associated parts such as springs, fuse links, and insulation.

The following abstracts of pertinent Standards are presented for reference and include only sections relative to temperature of contacts and terminals.

STANDARD 15, MARCH 1944, INDUSTRIAL CONTROL APPARATUS

Service conditions. When and where the temperature of the cooling medium does not exceed 40 degrees centigrade where the altitude does not exceed 6,000 feet.

Unusual service conditions. The use of apparatus in cooling medium higher than 40 degrees centigrade, and at altitudes greater than 6,000 feet should be considered special.

Limit of temperature rise for contacts. The temperature rise of contacts above the cooling air shall not exceed the following values:

Laminated contacts	50 degrees centigrade
Solid contacts	65 degrees centigrade
Busses, connecting straps, and terminals	50 degrees centigrade
Knife switch blades and jaws	30 degrees centigrade

Cooling air temperature. During test may be between 10 degrees centigrade and 40 degrees centigrade.

Method of measurement. Thermometer method. By mercury, alcohol, resistance thermometer, or by thermocouple.

STANDARD 16, JANUARY 1933, ELECTRIC RAILWAY CONTROL APPARATUS

Service conditions. When and where the temperature of the cooling medium does not exceed 40 degrees centigrade or the altitude does not exceed 3,300 feet.

Unusual service conditions. The use of apparatus with cooling medium higher than 40 degrees centigrade or at altitudes greater than 3,300 feet should be considered special.

Limit of temperature rise of contact. The temperature rise of contact above the temperature of the cooling air shall not exceed the following values:

Laminated contacts	50 degrees centigrade
Solid contacts	75 degrees centigrade

Cooling air temperature. During test may be between 10 degrees centigrade and 40 degrees centigrade.

Method of measurement. Thermometer method. By mercury, alcohol, resistance thermometer, or by thermocouple.

STANDARD 19, JUNE 1943, POWER CIRCUIT BREAKERS

(Superseded and replaced by ASA-C37.4–37.9.)

Usual service conditions:

(*a*). Where the temperature of cooling medium does not exceed 40 degrees centigrade if the circuit breakers have copper contacts or equivalent.

(*b*). Where the temperature of the cooling medium does not exceed 40 degrees centigrade if the circuit breakers have all conducting joints, including terminal connections, soldered or silver-surfaced and separately held mechanically, or brazed, welded, or silver-soldered, and all contacts silver-surfaced or equivalent.

(*c*) Where the altitude does not exceed 3,300 feet.

Unusual service conditions. The use of apparatus with cooling medium temperature higher than the foregoing or at altitudes greater than 3,300 feet is considered special and correction factors for the application should be used as follows:

Altitude in Feet	Correction Factors: Voltage	Correction Factors: Current
3,300	1.00	1.00
4,000	0 98	0.996
5,000	0.95	0.99
10,000	0.80	0.96

Limit of observable temperature rise. The temperature rise not to exceed values in following table:

	Limit of Temperature Rise, Degrees Centigrade: Oil Circuit Breaker	Oilless Circuit Breaker
Contacts in air when clean and bright	30	Not yet standardized, work in progress
Contacts in oil	30	
Oil	30	
All other parts	70	

Value of ambient temperature during test. Test may be made at any ambient temperature, preferably not below ten degrees centigrade.

Method of measurement. Thermometer method. By mercury, alcohol, resistance thermometer, or by thermocouple.

STANDARD 20, MAY 1930, AIR CIRCUIT BREAKERS

(This Standard is being revised.)

Usual service conditions. When and where the temperature of the cooling medium does not exceed 40 degrees centigrade and where the altitude does not exceed 3,300 feet.

Unusual service conditions. The use of apparatus with cooling medium temperature higher than 40 degrees

centigrade or at altitudes greater than 3,300 feet should be considered special.

Limit of temperature rise of contacts. The temperature rise above the temperature of the cooling air shall not exceed 30 degrees centigrade for contacts in air when clean and bright.

Cooling air temperature. During tests may be any temperature, preferably not below ten degrees centigrade.

Method of measurement. Thermometer method. By means of mercury, alcohol, resistance thermometer, or by thermocouple.

STANDARD 22, JUNE 1942, AIR SWITCHES AND BUS SUPPORTS

Usual service conditions:

(*a*). Temperature of cooling medium does not exceed 40 degrees centigrade if the air switches have copper-to-copper contacts or equivalent.

(*b*). Temperature of the cooling medium does not exceed 55 degrees centigrade if the joints are soldered, silver-surfaced, and separately held mechanically brazed, welded, or silver-soldered, and all contacts silver-surfaced or equivalent.

(*c*). Altitudes do not exceed 3,300 feet.

Unusual service conditions. The use of apparatus with cooling medium temperature higher than the foregoing and at altitudes greater than 3,300 feet should be considered special and correction factors as follows should be used:

Altitude in Feet	Correction Factor	
	Voltage	Current
3,300	1.00	1.00
4,000	0.98	0.996
5,000	0.95	0.99
10,000	0.80	0.96

Cooling air temperature. During test may be any temperature, preferably not below ten degrees centigrade.

Method of measurement. Thermometer method. By mercury, alcohol, resistance thermometer, or by thermocouple.

STANDARD 25, FEBRUARY 1945, FUSES ABOVE 600 VOLTS

Usual service conditions. When and where the temperature of the cooling medium does not exceed 40 degrees centigrade and where the altitude does not exceed 3,300 feet.

Unusual service conditions. The use of a fuse where the cooling medium is higher than 40 degrees centigrade or at altitudes greater than 3,300 feet shall be considered as special. For altitudes greater than 3,300 feet it is agreed provisionally that the permissible temperature rise during test at low altitudes (up to 3,300 feet) shall be less than that specified in these Standards by 0.4 per cent of the specified rise for each 330 feet of altitude in excess of 3,300 feet at which the actual installation is to take place.

Limit of temperature rise. The temperature rise shall not exceed:

(*a*). For all conducting parts of the fuse, except the conducting element, 30 degrees centigrade.

(*b*). Exception—fuses for railway service, for all conducting parts except the conducting element 50 degrees centigrade.

Cooling air temperature. During tests may be between 10 degrees centigrade and 40 degrees centigrade.

Method of measurement. Thermometer method. By mercury, alcohol, resistance thermometer, or by thermocouple.

STANDARD 27, AUGUST 1942, SWITCHGEAR ASSEMBLIES

Usual service conditions. When and where the temperature of the cooling medium does not exceed 40 degrees centigrade and where the altitude does not exceed 3,300 feet.

Unusual service conditions. The use of assemblies with cooling medium temperature higher than specified in the foregoing and at altitudes greater than 3,300 feet shall be considered as special applications and correction factors should be applied as follows:

Altitude in Feet	Correction Factors	
	Voltage	Current
3,300	1.00	1.00
4,000	0.98	0.996
5,000	0.95	0.99
10,000	0.80	0.96

Limit of temperature rise. The temperature rise of the devices used as a part of the switchgear assembly shall be as specified by the Standards for such devices.

Open switchgear. The temperature rise of busses and connections when carrying rated current should not exceed 30 degrees centigrade.

Enclosed switchgear. Average air temperature inside enclosure shall not exceed 15 degrees centigrade over the ambient air temperature outside the enclosure.

The temperature rise of busses and connectors shall not exceed 30 degrees centigrade over the ambient outside enclosure unless all joints and terminal connections within the enclosure are brazed, welded silver-soldered, soldered when separately held mechanically, and all contacts silver-surfaced or equivalent, in which instance the temperature rise shall not exceed 30 degrees centigrade over the average air temperature inside the enclosure.

Cooling air temperature. Tests may be made at any ambient temperature, preferably not below ten degrees centigrade. It shall be assumed that the temperature rise is the same for all ambient temperatures between

the limits of 10 degrees centigrade and 40 degrees centigrade.

Method of measurement. Thermometers or thermocouples may be used.

MISCELLANEOUS ESTABLISHED PRACTICES NOT COVERED BY STANDARDS

Various types of small and large circuit breakers with main contacts made of silver or certain silver alloys 45 degrees centigrade, 50 degrees centigrade, or 65 degrees centigrade rise with rated load on test have operated satisfactorily over many years.

Certain United States Navy specifications allow 65 degrees centigrade in 50 degrees centigrade ambient temperature and 75 degrees centigrade in 40 degrees centigrade ambient rise for circuit breakers with main contacts made of solid silver.

Switches used in connection with electric ranges usually are designed for temperatures of 120 degrees centigrade (80 degrees centigrade rise with 40 degrees centigrade ambient temperature). Switches with either silver or brass-to-bronze contacts have given satisfactory service.

Various plug-in contacts, as well as relay contacts made of silver or various other metals and alloys, have proved to be satisfactory for temperatures up to 370 degrees centigrade (330 degrees centigrade rise with 40 degrees centigrade ambient temperature) in connection with heating appliances.

(These practices merely indicate that Standards should recognize different temperature rises for different materials and other variations in design and service if both maximum economy and safety are to be realized.)

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Communications Center

High speed communications between all major points in the United Airlines system are being effected by means of a new communications switching center installed at Chicago.

Each message is typed only once, at the point of origin, on a machine which prints the message and perforates combinations of holes in a paper tape. The operator at the switching center reads the destination on the tape, presses a button which causes the tape to be fed through an automatic transmitter, and the message is received automatically at the destination in printed form. Illustration shows one bank of switching machines.

Joseph Slepian—Edison Medalist for 1947

Presentation of the 1947 Edison Medal to Doctor Joseph Slepian (F '27) "for his practical and theoretical contributions to power systems through circuit analysis, arc control, and current interruption" was made on Wednesday, January 28, during a general session of the 1948 AIEE winter general meeting at Pittsburgh, Pa. AIEE President Blake D. Hull presided at the session, at which the history of the medal was recounted by AIEE Director J. F. Fairman (F '35) representing S. M. Dean, chairman of the Edison Medal committee, and the medalist's career was outlined by M. W. Smith (F '42).

The Edison Medal

J. F. FAIRMAN
FELLOW AIEE

THE EDISON MEDAL was founded in 1904 by associates and friends of Thomas A. Edison who desired to commemorate the achievements of a quarter of a century in the art of electric lighting, and in particular the prominent part played in those achievements by Mr. Edison himself. As the most effective means of accomplishing this object, they established a fund, the proceeds of which are to be used to prepare a gold medal and certificate to be awarded each year to a resident of the United States or Canada for meritorious achievement in electrical science, electrical engineering, or the electrical arts.

The purpose of the medal is threefold—not only is it to commemorate the genius and accomplishments of Mr. Edison, but also to serve "as an honorable incentive to scientists, engineers, and artisans to maintain by their works the high standard of accomplishment" which had been set by Edison. Moreover, it establishes an honorable company of those who have achieved distinction in that field.

To assure the continuity of the medal, the founders invited the AIEE to undertake the responsibility of making the awards. The AIEE accepted that responsibility, and, to administer it, organized the Edison Medal committee.

The medal was designed by James Earle Fraser. On the obverse it carries a portrait of Edison and on the reverse side an allegorical conception of the genius of electricity crowned by fame.

The first award of the medal was made in 1909 to Doctor Elihu Thomson and an award has been made each year since—save two—until the roll now carries 36 names. We are met today to add another to that illustrious company of those who have given so freely of their genius and efforts to carry forward the torch kindled by Mr. Edison and his associates and to honor one who has contributed greatly toward making electricity the servant of mankind.

Full texts of the addresses made at the Edison Medal presentation, January 28, 1948, during the 1948 AIEE winter general meeting, Pittsburgh, Pa.

J. F. Fairman is vice-president, in charge of production and operation, Consolidated Edison Company of New York, Inc., New York, N. Y.

The Medalist

M. W. SMITH
FELLOW AIEE

WE HAVE BEEN hearing much about the "sonic wall." Electrical science, too, has had its barriers, not so spectacular perhaps, but none the less real. About 1920 it became evident that if lightning protection were to keep pace with the rapidly expanding power systems, some new principle would have to be employed. The limit to the abilities of the electrolytic

M. W. Smith is vice-president in charge of engineering, Westinghouse Electric Corporation, Pittsburgh, Pa.

arrester about had been reached. Then, as power systems continued to grow, the ability of circuit breakers to interrupt the enormous potential short circuits seemed faced with a stalemate. Again, as engineers in the early '30's were struggling to convert the attractive mercury-arc-rectifier principle into economical, reliable, heavy-power devices, their efforts appeared hopelessly blocked by the phenomenon of arc-backs that had defied explanation.

These are three famous barriers, surmounted in the evolution of electric-power apparatus. There have been numerous others. But we are interested in these three particularly because the man who did most to help "break through" them is the man we are here today to do honor—Joseph Slepian. Furthermore, these three are not the total but are only representative of the accomplishments of Doctor Slepian which have led the committee wisely to select him as the recipient of the Edison Medal. In the words of the committee, he is being signalled for honor "for his theoretical and practical contributions to power systems through circuit analysis, arc control, and circuit interruption."

EARLY CAREER

Joseph Slepian, a native of Boston, Mass., entered Harvard University in 1907 at the age of 16 and received there his bachelor of arts degree in 1911, and his doctor of philosophy degree in mathematics two years later. As a Sheldon Fellow, he spent a year as postdoctorate student at the University of Göttingen, in Germany, and at the Sorbonne, in Paris. Upon his return, he accepted a position at Cornell University as an instructor in mathematics, but after only a year of teaching he astounded his colleagues by resigning his university post and joining Westinghouse as a graduate apprentice. This was the beginning of his remarkable career that enriched the science of electrical engineering with invaluable contributions.

HIS METHOD

Doctor Slepian's achievements are remarkable examples of research at its best. The triumphs of many inventors have been accidental, but not his. He approaches his problems as a scientist, with a systematic analysis; establishes all pertinent facts about them as a thorough experimentalist; and after organizing and co-ordinating the facts, he formulates a theory governing the principles of their operations, concluding with a commercially practical solution. This happy interplay of theory, experiment, and genius created many new developments in lightning arresters, air and oil circuit breakers, fuses, rectifiers, and other electronic devices.

Doctor Slepian's work which led to the development and use of the autovalve lightning arrester is a striking example of research and invention directed toward a preconceived and clearly defined end.

Late in 1920 it became apparent to those charged with the responsibility for design and application of lightning-protection devices that the highly effective electrolytic arrester would not meet all of the requirements of the expanding transmission and distribution systems because of expense of both installation and maintenance, and because of the likelihood that a storm would find an arrester in an inoperative condition. No suitable alternate principle appeared to be available.

The problem was put to Doctor Slepian to devise a principle of operation on which could be built an arrester with operating characteristics similar to those of the electrolytic arrester but without its use of liquids and without requiring daily or weekly charging and annual complete overhauling.

His first step—a complete analysis of the operation of electrolytic arresters during a discharge—resulted in recognition of a countervoltage as necessary to block power current after passage of the surge. This original concept of arrester operation opened the way to a solution to the problem.

He then searched for an alternate means of providing such a countervoltage and hit upon the glow discharge in air as the most feasible means. This was followed by a study to determine the conditions necessary to initiate and maintain a glow discharge, with currents of magnitudes and durations then supposed to comprise lightning discharges on transmission systems. This led to the development of an autovalve arrester using tiny gaps between flat plate electrodes of considerable resistivity.

While apparatus using this new principle was being developed and proved in use, Doctor Slepian contributed continuously not only to this phase of the work but also to the general study of characteristics of thunderstorms and lightning discharges on transmission and distribution circuits. This resulted in a complete revision of the conceptions of the phenomena with which lightning arresters have to deal, at the same time helping to keep the apparatus development in step with this growing understanding.

Several years later, he devised a new arrester principle employing multiple arcs in restricted passages, instead of glow discharges, as a means for securing the necessary countervoltage characteristics. This led finally to the present form of autovalve arrester using the familiar "porous block."

Most of the inventions and the advancements Slepian made in the theoretical side of electrical engineering involve conduction of electricity through gases. Not only has he put the theories of other physicists to practical use, but also has himself made many new discoveries and contributed greatly to the understanding of phenomena in gas discharges.

THE ARC-CATHODE THEORY

An important part of Doctor Slepian's work centered around the theory of the arc cathode, its formation and

extinction, he being one of the first to recognize the existence of "cold-cathode" heavy-current arcs. His experiments with rapidly moving arcs showed that the cathode could exist at electrode temperatures too low for the thermionic emission required by the "thermionic cathode theory" which at that time was the only recognized one. He also discovered that arcs of low-pressure low-current density exist in contradiction to generally accepted theories. To explain their existence he formulated a theory based on thermal ionization of gases near the cathode.

The practical result of these studies was the invention and development of the first successful air "power" circuit breaker. To apply the theories in practical form, a structure was provided consisting of a number of plates with circular annular paths between them. Around these the arc was made to move so rapidly that a hot spot could not be formed, thus maintaining the cold-cathode action. This resulted in practically instantaneous dielectric buildup following current zero. To handle the higher voltages, capacitor shields were added to maintain practically uniform voltage across the stack of plates. Thus were developed the three fundamental features of the deion circuit breaker: the cold cathode, the annular path, and the resultant voltage distribution.

Doctor Slepian was the first to put on a sound and quantitative basis the theory of the extinction of a-c arcs. Prior to his classical papers on this subject in the AIEE *TRANSACTIONS*, the extinction of arcs was understood only in a vague and empirical way. He showed clearly the importance of the cathode part of the discharge for short-arc extinction, as well as all the factors of turbulence and diffusion which enter into the conditions for extinction of long arc columns. He correlated the transients of the electric circuit supporting the arc with the dynamic characteristics of the arc, to establish criteria for arc extinction or arc reignition. He created the graphic picture of arc extinction as a race between the rate of recovery of system voltage as against the rate of recovery of the dielectric strength of the extinction medium. This concept is of importance as it introduces the factor of system characteristics into circuit breaker problems.

THE ARC-BACK

As late as 1929, the multianode mercury rectifier fell far short of the capabilities which appeared to be inherent in the principle. The failure seemed chargeable to the insufficiently explained arc-back phenomenon. Foreign gases had been accepted generally as the major source of arc-back, other sources of design faults being thought to have been eliminated. However, the development had reached an impasse. The mercury-arc rectifier, though commercially useful, was far below its potentialities.

At this point Doctor Slepian became interested in the problem. Again he rationalized the conception of arc-back by introducing the idea that an arc-back is a chance phenomenon arising from the occasional combination of a great number of more or less independent variables.

Suspected as one of the major contributors to the occasional arc-backs was the presence within the same chamber of other anodes carrying heavy currents, which were prolific sources of ionization affecting the insulating paths in a widely variable degree. This led to the conclusion that the best attack would be to separate the anodes into individual chambers, and was the first step toward the Ignitron idea.

Slepian and his associates then reasoned that the job of eliminating sources of ionization during the blocking period would be only half done if continuous excitation arcs were employed. Then followed an intensive research to provide a means of initiating the arc afresh each cycle, dependably, when required, and without appreciable time lag. Thus the ignitor scheme resulted, which has acheived the success now so well known. More than 4,000,000 kva in Ignitrons have been installed in the last decade.

OTHER CONTRIBUTIONS

The contributions of the medalist have covered many other fields. Some of his earliest work dealt with space charges, with the theory of arcing grounds, with energy flow in electric systems, theoretical and experimental work on barrier films in electrolytic apparatus, theoretical work on semiconductors, and so on. He patented, in 1927, the idea of accelerating electrons by magnetic induction which is the basis of what is known today as the betatron. More than 200 patents are to his credit.

During the war, Doctor Slepian was active in the development of the atomic bomb. He is still at work on problems of related nature, full details of which cannot yet be disclosed.

For many years he has organized and taught classes in such subjects as vector analysis, theory of electricity and magnetism, kinetic theory of gases, and the conduction of electricity through gases. In this way and through personal contacts he has made valuable contributions to the training and education of young scientists and engineers.

His sound understanding of both the physical and mathematical basis of engineering and his ability to explain phenomena and the solution of problems with unusual clarity and simplicity has made his advice eagerly sought by his associates.

As a person, Doctor Slepian is a remarkable individual. Nature has endowed him not only with passionate curiosity and creative imagination, but also with the critical mind of a mathematical analyst. At the same time he is extremely human. He loves music, art, and literature. His conversation is provocative and often

plays havoc with one's complacency. He has a keen wit, but his whimsey springs from a depth of thought and emotion. His jests reveal the meditative philosopher who abhors the dishonesty and hypocrisy of our modern society while laughing at them. His attitude toward life is a mixture of unpretentious simplicity and frankness, with a high regard for the real and lasting values.

He has the unusual ability to see beyond existing barriers of equipment and to enunciate principles that open the way for further progress. Moreover, his works suggest the general method of attack that may be used to overcome the barriers to be met in the future.

I have known Doctor Slepian and his work for many years, and welcome this opportunity to express my admiration of his achievements and my highest regard and esteem for his outstanding qualities, ability and his good fellowship.

The Mathematician, the Scientist, the Engineer

JOSEPH SLEPIAN
FELLOW AIEE

THAT A MAN with my particular kind of talents, abilities, and personality should win a high engineering honor may seem very remarkable. Particularly is this the case for the Edison Medal, where the emphasis naturally would be put on achievement in practical invention, the founding or furthering of new industry, or the advancement of applied technology. The dominant interest of my youth, and the kind of formal education it led me to acquire, certainly did not presage distinction in such fields.

Unlike my predecessor, the Edison Medalist of last year, emulation of Mr. Edison was not my strongest boyhood desire. The "Wizard of Menlo Park" was a fabulous and renowned figure on the American scene, but to me it was a rather remote figure, and did not arouse in me the overpowering ambition to "go and do likewise." My great absorption in my 'teens was in mathematics. Poverty, and its compulsion to carry on various menial jobs to feed and clothe myself, kept me in very intimate contact with the real physical and social world, but my great joy was in that other world of abstract thought, where I could contemplate the beauties of mathematical structures subject only to the requirement of logical consistency. I was a pure mathematician. I was happy to study how things, objects of thought, might fit together, or what were the possible systems of order.

The physical sciences also fascinated. The objects of the physical world, constructs of our direct experience, also fitted together into a logically consistent scheme or order. Of the possible orders studied by the mathematician, what was the actual order found in nature? Because I was interested intensely in the answer to this question, I was a pure scientist.

But now, the record indicates that I am a practical engineer. It credits me with inventions in wide, practical use in the electrical industries. My publications have been mostly in engineering journals such as that of this Institute. How did such beginnings lead to such ends?

This raises some interesting questions. What is a mathematician? What is a scientist? What is an engineer? What are their relations to one another? Should an engineer be trained as a mathematician? As a scientist? What is the place of the mathematician or scientist in engineering organizations?

These questions are particularly timely and important because of the spectacular contribution which scientists as distinguished from engineers have made in that titanic engineering contest, the recent devastating war. Does this mean that the men who come out of our graduate schools of pure science make better engineers than those with more conventional engineering training? Should engineering organizations endeavor to recruit their staff from holders of doctor of philosophy degrees in mathematics, physics, or chemistry rather than from mechanical engineers, electrical engineers, or chemical engineers? Should young men desiring to enter the engineering profession seek out the scientific rather than the technical schools?

However important these questions may be, I cannot possibly answer them in the space of this address. I may point out, however, that any discussion of these questions will be futile unless some time is spent in defining the terms "mathematician," "scientist," and "engineer" in a way which displays their distinguishing characteristics. This is necessary because, as generally used, these terms have quite completely overlapping connotations. Mathematics generally is classed as a science, and ordinarily we speak of the engineering sciences. Many distinguished mathematicians have made great contributions to physics and chemistry, and frequently, distinguished scientists also have been distinguished engineers. Evidently, before we can have any profitable discussion of the questions I have raised, we must redefine and narrow the meanings of the terms mathematician, scientist, engineer, so as to emphasize what essential differences may exist among these three professions.

Perhaps then in this address I can make a contribution by attempting such a redefinition.

I am told that when Mr. Edison was proposed for election to an eminent honorary scientific society, a serious discussion arose as to whether Mr. Edison was or was not a scientist. Such discussion was possible only because the various discussors gave different

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meanings to the word scientist. The discussors would have been better scientists if they had limited their enquiry to determining the meaning attached to the word scientist by the framers of the charter of the organization, in which case the eligibility of Mr. Edison would have been evident.

I have pondered on what rightly may be called the really distinctive features of the mathematician, scientist, and engineer. There seem to be two ways of logically distinguishing among them. One, which has perhaps the wider popular appeal, is by the kinds of skills they display in their activities and the kind of accumulated knowledge of which they make use. It emphasizes their crafts. The other, and which I think strikes deeper, is by their motivations or compelling interests. It emphasizes their professions. I shall use this second means of distinction as the basis of my definitions of the mathematician, scientist, and engineer.

Let me proceed then to ask these questions. When the mathematician is doing that which is uniquely mathematics, and cannot possibly be said to be physics, or chemistry, or other science; when the physicist, as a typical scientist, is doing that which is uniquely physics and cannot be said to be mathematics or engineering; when the engineer is doing that which is certainly engineering; what are their respective distinctive motivations and compelling interests?

My answers lead to the following definitions.

THE MATHEMATICIAN

The "mathematician" is one whose interests and activities lie in determining and studying how things *may* fit together, that is, what are *possible* systems of order, and what are the details of such possible systems of order.

May things fit together like the points, lines, and planes of Euclid? May they fit together in somewhat different ways? What are the details of such possible Euclidean and non-Euclidean geometries? Such are the questions which concern the mathematician.

The extraordinary or perhaps defining thing about these possible systems of order of the "mathematician," is that although each generally has infinite and intricate detail, yet generally, each uniquely may be characterized or defined by only a few and, usually simply stated, degnitions and postulates. The infinite detail then may be unravelled by a process of logical or mathematical reasoning. We are all familiar with this process through our studies of Euclid in high school.

As the "things" which the "mathematician" studies are abstractions, defined only by their postulated relationships, the mathematician needs no laboratory, but marks on a pad of paper, symbols, give whatever concreteness his mind needs. He then develops skills and techniques in manipulating these symbols, and it turns out that these skills and techniques are useful also to the "scientist" and the "engineer."

THE SCIENTIST

The "scientist" is one whose interests and activities lie in determining what is the *actual* order of things in the physical world and studying the details of that order. What experiences may he have with the physical world and how do these experiences fit together?

What experiences may he have with actual fluids? How do the observed pressures, flows, and waves fit together? What are the details of this mechanics of fluids? Such are the questions which concern the physical "scientist."

The "scientist" then develops skills and techniques and a body of knowledge suitable to his activity. As he deals with actual things in nature, and not simply with possible things or abstractions, he needs laboratories where he can undergo his experiences under well-controlled conditions so that he better may discover their order or relationships, this being his ultimate objective.

The details of the actual order in nature are infinite in number and intricacy. The "scientist" hopes, and works under the hypothesis that it is true, that the actual order will be one of the possible orders studied by the "mathematician"; namely, one that is described completely by a few, simply stated general principles, and such that the details then may be worked out by the process of logical or mathematical reasoning.

In trying to discover the actual order in nature, the "scientist" will consider what are possible orders in the sense of the "mathematician," and must have the capacity to work out the details of such possible orders so that comparison with experience most readily can be made. His activity then becomes almost identical with that of the "mathematician." But what distinguishes him from the "mathematician" is his motivation. The *possible* system, when it fails to correspond to actual experience, is rejected by the "scientist," but may remain as a proper field of study for the "mathematician."

Obviously the accumulated knowledge of the "scientist" of how things fit together in the physical world will be useful to the "engineer," provided the "engineer" also has the "scientist's" and "mathematician's" technique of arriving at the knowledge of details from general principles by logical or mathematical reasoning.

THE ENGINEER

To define the "engineer," I need to bring in the notion of practical value or utility. The popular meaning of this term is sufficient for my purpose, and I do not need to go into the ethical or philosophical aspects of value or utility. I shall say that a thing or service has practical value or utility if it is of a material or physical character, and if a group of people regard that thing or service as so sufficiently desirable, that they will pay for

President Hull (right) presenting the Edison Medal to Doctor Slepian

cost for the services which the "engineer" brings into being, cannot be eliminated. If the "engineer" is a sympathetic member of a dictatorship state, he may have satisfaction in believing that those who control, and thus have the capacity to pay, know best what people should desire in the way of material services and satisfactions. On the other hand, if he is a sympathetic member of a free enterprise system he may rejoice that people freely may choose their own material services or satisfactions limited only by their willingness and capacity to render corresponding services to others.

When, in my first contact with the Westinghouse Corporation I found myself deriving great satisfaction from the thought that this railway motor which I was winding in this shop, this embodiment of Faraday's law of induction, soon would be carrying people about on their business and pleasure, I knew I was an "engineer." And recently, when I visited the great plant at Arvida, Canada, and saw the row after row of Ignitron rectifiers, based on the science of the conduction in gases, and producing tons on tons of much desired aluminum, the thrill which I received showed that I still am an "engineer."

that thing or service more, or at least not less, than it costs to bring it into being.

I might define the "engineer" then as one whose interests and activities lie in devising, designing, constructing, or controlling the operation of physical devices, machines, technical processes, or services which have practical utility. To distinguish the engineer from the skilled artisan, the businessman, the artist, or the author who also might be construed as carrying on such activities, I add the additional requirement that in carrying on his utilitarian work, the "engineer" must make active use of skills, techniques, and accumulated knowledge such as the "mathematician" and "scientist" use and develop for their purposes.

Edison then was an "engineer." The practical utility of his inventions was the spur to his intensive labors. But the details of his activity resemble very much the activity of Faraday the "scientist," whose journal I am told Edison read avidly. Seeking out the things in nature, examining them in the laboratory to determine their relationships or order, the making of hypotheses as to what that order might be, and testing them by experiment, these are skills and techniques of the "scientist" which Edison used constantly.

The motivation which I give to the "engineer" in my definition may seem to some crass and materialistic. That is a matter of taste. The "engineer" regards serving and satisfying the material needs and desires of people as a laudable and satisfying activity, which needs no further justification.

The requirement that some groups value sufficiently and have the capacity to pay at least not less than their

My predecessor, the Edison Medalist of last year, a great "engineer," also records his satisfaction in successfully applying the theories and discoveries of the "scientist" Hertz to the satisfying of the multifarious material needs and desires of man.

As part of my definition of the "engineer," I require him to make active use of the accumulated knowledge, skills, and techniques of the "mathematician" and "scientist." He also, of course, will develop and accumulate certain knowledge, skills, and techniques of his own. He must know properties of materials, particularly with respect to their production, fabrication qualities, and costs, things which may be of little interest to the pure "scientist." Where the theories and techniques of the "mathematician" and "scientist" are insufficient, he must know what information he needs for his purposes and acquire it by test and experiment, recording it in tables of empirical data, or embodying it in empirically established practices. He must be acquainted with the methods and principles which "engineers" have developed in the past. He must know hydraulics as well as hydrodynamics, heat engines as well as thermodynamics, dynamoelectric machinery as well as electromagnetism. He must have test floors and pilot plants as well as laboratories.

I now should use these special definitions which I

just have given, to discuss those earlier questions which induced them. However, time will not permit this. Instead I will take up another phase of the relationship between "mathematician" and "scientist" to the "engineer" which was emphasized by the war and which leads to the question of the proper support of the "mathematician" and "scientist" in this modern technological world.

During the war "mathematicians" and "scientists" made very great contributions to ballistics, aeronautics, submarine detection, radar, the proximity fuse, the atomic bomb, and numerous other "engineering" activities. The valuable results obtained depended on the "mathematician" and "scientist" temporarily adopting the motivation of the "engineer." There is, however, a transient element to the success of these temporary "engineers."

These "scientists" were, of course, deficient in the special skills and knowledges of the conventional "engineers," but this was more than counterbalanced by the advanced knowledge and skills which they had acquired during their careers as "scientists." Presently, those parts of these skills and knowledge which have technical utility will be part of the regular training of "engineers," and presently the "engineers" will be doing these things better than the scientist-"engineer." Using scientists in "engineering" projects is then a kind of drawing on reserves accumulated while they were "scientists." While engaged in this "engineering" work these reserves will run down and be depleted if the scientists do not return to being "scientists."

We know now that while "mathematicians" and "scientists" carry on their activities for "their own sake," that is for aesthetic reasons or other intellectual satisfactions, nevertheless, their work will lead to radical and revolutionary advances in technology in the future. The invention of a number system in which all algebraic equations, even $x^2+1=0$, have solutions, had to be done by the "mathematician." The "engineer" could not anticipate its utility for solving practical a-c problems. Only a "physicist" would be engrossed with the faint glows given off by certain rare minerals. How would the "engineer" know that these faint glows were the indications of tremendous technically utilizable forces within the atom?

With these examples before us, we see that while there are also other important reasons, we must support "mathematics" and "science" in the United States because of the inevitable future advances in technology which they will induce. To make "mathematics" and "science" flourish, we must create for "mathematicians" and "scientists" a favorable atmosphere.

High above all other requirements in this favorable atmosphere is that of freedom; freedom to choose their work or object of interest, freedom to write and publish, freedom to communicate with their fellows. Other requirements are a respected place in the community, proper working facilities, laboratories, libraries, and so forth, adequate compensation comparable with other professions.

In certain instances, and to a moderate degree, the funds for these purposes may come by employing the "mathematician" or "scientist" on some phase of applied or "engineering" research. However, if this method is applied extensively, it will defeat its own purpose. "Mathematicians" and "scientists" will be converted into mathematician-"engineers" and scientist-"engineers."

I now only am repeating in my particular way the message which many others have given recently since the close of the war. The future technological well-being of the United States needs for its maintenance not only the more immediate effects of applied scientific research, but also the long range effects of fundamental, basic, or pure scientific research. By this last is meant the activities of "mathematicians" and "scientists."

Thomas A. Edison and Michael Faraday according to my definitions are archetypes of the "engineer" and "scientist." It is interesting to observe their fecund relationship. Both worked assiduously in the laboratory, gathering orderly experiences with the physical world.

Faraday, the "scientist," discovered the law of electromagnetic induction, which some decades later, Edison the "engineer" applied to the creation of great electric power generating and distributing systems. Had Faraday been an "engineer" he would have found other more immediately utilitarian and therefore more interesting phenomena to investigate than the feeble and transient effects produced by moving a magnet near a coil of wire. Faraday, the "engineer" never would have made his great discovery.

On the other hand, had Edison, the "engineer," been a "scientist" when he discovered the Edison effect, the realization which he must have had that this obscure phenomenon could be revelatory of the innermost electrical nature of matter, would have attracted him as a "scientist" far more than his practical problem of the "subdivision of the electric light." In that instance the great "engineering" achievement of distributing the material blessings of electricity greatly would have been delayed. It remained for J. J. Thompson and other "scientists" to elucidate the Edison effect and to discover the electron and modern "physics" which again is serving as the fertile field for technological advances by modern "engineers."

Decades elapsed between the discovery of Faraday's law of induction, and the construction of Edison systems. Our present-day world moves much faster. Now new "scientific" discoveries are followed by "engineering" applications in only a few years. It is all the more necessary for technological progress that our present-day Faradays continue to function as "scientists" in fruitful symbiosis with our modern Edisons.

ABSTRACTS... OF AIEE TECHNICAL PROGRAM PAPERS

TECHNICAL PAPERS previewed in this section will be presented at the AIEE Great Lakes District meeting, Des Moines, Iowa, April 1–3, 1948, and will be distributed in advance pamphlet form as soon as they become available. Members may obtain copies by mail from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstracts; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk. Prices of copies to nonmembers will be twice those for members, less five cents for mailed copies.

MAIL ORDERS will be filled as pamphlets become available.

ABSTRACTS are prepared by the authors of the papers and approved by the technical program committee.

Basic Sciences

48-111—Experimental Determination of the Capacitance of Heavy-Current Busses Comprised of Solid or Tubular Rectangular Conductors; *Robert D. Teasdale (A '46), Thomas J. Higgins (M '46). 30 cents.* Knowledge of the line capacitances is required for accurate calculation of transient recovery voltages and other factors involved in designing the protective relaying of industrial distribution busses, central station busses, and other heavy-current systems. Equations for determining the capacitances of busses comprised of solid or tubular rectangular conductors, the shapes commonly used in practice, are not available: The mathematical analysis required for derivation has proved intractable. Experimental determination of these capacitances, however, can be effected in the simple fashion discussed in this paper. The basic theory of this method is outlined. Description of the apparatus required and a preferred technique of procedure are discussed. Curves for the capacitance and elastance of a bus comprised of coaxial rectangular conductors or of a rectangular conductor isolated in a concrete cell are given. An experimentally determined, generally applicable equation for the particular case of square conductors is obtained; confirmatively, it yields values lying between mathematically predicted bounds. Extension of the experimental procedure for determination of the capacitances of capacitors of arbitrary 2- or 3-dimensional geometry is explained. Finally, it is shown that the experimental procedure can be used to obtain the inductances of complex high-frequency transmission lines such as those comprised of an array of split conductors.

Communication

48-113—An Optical Radar for Surveying; *W. W. Hansen. 30 cents.* An instrument has been developed for surveying terrain by the use of radar techniques. The instrument transmits pulses of light from a flashlamp to a retrodirective reflector placed at the point whose position is to be determined. The light returning from the reflector falls on a photomultiplier whose output is amplified to produce a pip on a cathode-ray tube. Distance is measured by determining the transit time of the pulse of light. This is accomplished by auxiliary circuits which include a local crystal-controlled oscillator. These auxiliary circuits produce timing markers on the tube which can be made to match the pip produced by the returning light. Angles are measured with the scribed circles of a conventional transit. The angular position of a reflector is determined with considerable precision by orienting the transmitter-receiver unit to obtain a maximum return pip. The optical system makes use of a single parabolic searchlight mirror, the outer portion of which is used for the transmitted beam while the inner portion is used for the received beam. The whole equipment operates alternatively from storage batteries or from 110 volts alternating current. It is designed to be separable into several units for easy transportation.

Electronics

48-102—Amalgam-Cathode Materials for Power Tubes; *J. A. M. Lyon (M '47), C. E. Williams. 30 cents.* Studies involving the use of tin-, lead-, sodium-, and magnesium-amalgam cathodes in place of the usual mercury-pool cathode are described in this paper. A primary objective of this research has been to obtain an amalgam which retains the tremendous emission capabilities of mercury, and yet to have a solid or rigid cathode so as to allow jarring, tilting, or complete inversion of the tube without adverse effect on the tube operation. Test results indicate that tubes utilizing sodium-amalgam cathodes may be operated in the inverted position for short times; these tubes also have a higher efficiency than mercury-pool tubes. This latter fact is in accordance with the low ionization level of sodium.

Instruments and Measurements

48-104—Primary Detectors for Measurements; *E. E. Lynch (M '35), A. J. Corson (M '43). 30 cents.* The functional analysis of measurements defines the primary detector as the first element or group of elements that responds quantitatively to the quantity measured and performs the initial measurement operation. This paper is the result of a detailed study of this concept, and its application to approximately 100 measuring devices. After determination of how much of a measurement sequence is contained in the primary detector, its input-output characteristics are examined both by practical example and by reference to the ideal element. The energy input and output of primary detectors differs, in general, from the functional input and output, as most practical measurements are inferential in character. The application of primary detectors to measurement systems is summarized in tabular form with data on range of use, basic elements utilized, input, physical effect, and output. The pertinent physical effect is discussed as the basis of mathematical analysis of the detector operation. This survey shows a great diversity of measurement methods and the consequent value of a broad systematic treatment.

Metallic Rectifiers

48-101—A Practical Approach to Calculating Optimum Performance of Semiconductor Rectifiers; *Earl D. Wilson. 30 cents.* Applying Kirchoff's circuit laws to a conventional 4-arm rectifier bridge, an expression is derived for efficiency in terms of R (effective reverse resistance of one arm), F (effective forward resistance of one arm), and L (ohmic load resistance). Knowing that R and F can be kept constant by separate adjustments of input voltage and temperature of the cells enables us to maximize efficiency, E, with respect to L. The optimum value of L turns out to be $\sqrt{RF}$, the geometrical mean of forward and reverse resistances. This value of L yields $E_{\max} = [(q-1)/(q+1)]^2$, where $q = \sqrt{R/F}$. Further analysis shows that $\sqrt{R/F} = V_R/V_F$ for optimum L, where V_R and V_F are corresponding values of reverse and forward voltage drops, so that $E_{\max}$ is expressible in terms of V_R and V_F alone. Three families of curves are given to illustrate manipulation of the simple empirical data required, resulting in a final plot of $E_{\max}$ versus temperature for various current densities in the cells. An important feature of the process depends on the interesting analytical result that for maximum efficiency the reverse and forward losses are equal, making it possible to correlate values of V_R and V_F. Because the empirical data involved are strictly applicable only when R and F are not appreciably affected by previous values of V_F and V_R respectively, a modified technique is suggested in which data are observed only when optimum L is in the circuit. It is

shown that under these conditions $E_{max} = (V_L/V)^2$ where V_L is the rms drop across L and V is the a-c input voltage. Interpretation of results is discussed.

Rotating Machinery

48-109—Oscillographic Study of Synchronous Motor Hunting; *E. B. Kurtz* (*F'29*). *30 cents.* A laboratory synchronous motor is subjected to 150 per cent full load impact loading. Oscillograms of all the electrical quantities including power angle are recorded for various values of field current. Seven oscillograms for loading and six for unloading are shown. A special power angle recording device giving a linear record is employed. From the oscillograms, analyses of hunting frequency, magnitude of oscillation, power factor, and so forth, are made. Hunting frequency is found to differ considerably for loading and unloading.

Standards

48-110—Progress Report on AIEE-ASME Standard Large 3,600-Rpm Turbine-Generators; *S. H. Mortensen* (*F'20*), *J. B. McClure* (*A'29*), *C. M. Laffoon* (*F'45*). *30 cents.* In October 1944 the report of the joint AIEE-American Society of Mechanical Engineers committee on proposed preferred standards for large 3,600-rpm 3-phase 60-cycle condensing turbine generators was made available to the AIEE Standards committee. In 1945 AIEE Standard 601, covering the joint AIEE-ASME preferred standards for large 3,600-rpm condensing steam turbine-generators, and AIEE Standard 602, covering standard specification data for generators for large 3,600-rpm condensing steam turbines, were approved. The units covered by the standards included 11,500- and 15,000-kw air-cooled generators; and 20,000-, 30,000-, 40,000-, and 60,000-kw hydrogen-cooled generators rated for 0.5 pound per square inch (gauge) hydrogen pressure. The present report is a survey of the progress made by manufacturers in developing and building the units, and the degree of acceptance of the program by the electrical utility industry. On the basis of the data and the general situation associated with the production of the new standard line a number of conclusions are drawn:

1. All standard line units are now available with the exception of the 15,000-kw rating.

2. Purchaser acceptance has been wide, and the number of units and total kilovolt-amperes now on order represent 35 to 40 per cent of the total turbine generator business for units of 10,000-kw rating and above.

3. It is anticipated that in 1948 and thereafter, orders placed for new units will be almost exclusively of the new standard line for the range of ratings covered by this line.

Based on comments and suggestions from purchaser and manufacturer groups, recommendations are made that the 15,000-kw unit be reconsidered for design for hydrogen cooling and have the same characteristics as the larger units; that AIEE Standard 602 be reviewed for major changes; and that the advisability of standardizing the next larger 3,600-rpm unit for ratings of 80,000 and 90,000 kw be considered.

Switchgear

48-106—A New Relayed Automatic Oil Circuit Recloser; *E. J. Casey* (*M'42*), *E. T. McCurry* (*A'40*). *30 cents.* Fourteen years' experience in the operation of single-pole automatic reclosing oil circuit breakers on rural electric lines has proved the value of this device. In recent years, wider applications of the oil circuit recloser, as it commonly is called, have shown the desirability of an improved operating characteristic which will allow a much wider co-ordination of the reclosers with themselves and with the distribution fuse links. This paper describes a new oil circuit recloser in which a greatly improved operating sequence is obtained through the use of a mechanical system operating in air so that the characteristic does not change with the change in ambient temperature.

48-107—Modern Design Conceptions Are Used To Make Improved High-Voltage Switches; *A. H. Powell* (*A'43*), *H. R. Harrison*. *30 cents.* The disconnecting switch is a familiar device to most engineers, especially to those interested in the transfer of electric power. Many switches are available on the market today incorporating various features, methods of operation, and principles which may or may not make them satisfactory for the present-day requirements. The term "modern design" brings to mind streamlined appearance, simplicity and reliability in operation, but above all, a device which has been built in light of advanced techniques and know-how that have evolved in the last few years. This conception now has been applied to the high-voltage air switch in light of the user's requirements resulting in a design which will be reviewed in this paper.

48-108-ACO—Power Air Circuit Breakers In Metal-Clad Switchgear; *R. C. Dickinson* (*M'41*), *B. I. Hayford* (*A'23*). *30 cents.* This paper includes a review of the structural development of magnetic-type power air circuit breakers, beginning with application of the first of such circuit breakers in 1929 on 12-kv circuits at 500,000-kv interrupting rating. A variety of structural types is described with photographic illustrations. The evolution of these devices from stationary frame mounting to their application in full metal-clad switchgear is described. Up-to-date designs of drawout circuit breaker units are described together with corresponding features of the complete switchgear. The flexibility of basic housing designs for the various circuit breaker ratings and to meet a variety of bus arrangements and other special conditions are described.

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Transmission and Distribution

48-103—The General Solution Method of Power Network Analysis; *Lyle A. Dunstan* (*A'40*). *30 cents.* This paper illustrates the complete analysis of a network by the computation of a set of coefficients describing the effects of power load, reactive power load, power generation, reactive power generation, transformer ratio, and phase shift at each point in the network upon power flow, reactive power flow, voltage, and phase angle at all points in the network. Methods also are discussed for using the coefficients when: the impedance between two network points is desired; an impedance is changed; a new circuit element is added; and two networks are to be interconnected. In the field of applied mathematics, the paper shows how the use of the inverted matrix and network coding results in great economy of labor over computing the coefficients using conventional star-delta transformations or simultaneous equations. The method is worked out exactly for a d-c network, and extended by suitable analogy and approximations to the a-c network. The coefficients may be used to carry through successive approximations converging upon precise answers for a-c networks without the solution of simultaneous equations.

48-112—A Large-Scale General-Purpose Electric Analogue Computer; *E. L. Harder* (*M'41*), *G. D. McCann* (*M'44*). *30 eents.* This paper describes the development of a large-scale general-purpose analogue computer designed primarily to solve transient problems in electric circuits, electromechanical systems, and applied mechanics. The design is based on several years experience with smaller machines. The number of units greatly has been increased, several new and important components have been added, and all existing elements completely have been redesigned and improved. The new elements include special transformers, multipliers, and forcing functions. The paper covers broadly the design principles of the computer and of the newly designed elements. It outlines the method of solution by electrical analogy, and the functions performed by various elements of the computer. It describes the application to typical problems in the electrical and mechanical fields.

INSTITUTE ACTIVITIES

Final Plans Are Announced for Conference on Electron Tubes

Plans substantially are completed for a very interesting conference on electron tubes for instrumentation and other industrial applications to be held at the Benjamin Franklin Hotel, Philadelphia, Pa., March 29–30, 1948. The conference is divided about equally between informational talks on this and related subjects and discussion periods, particularly on specific tube types, in which it is hoped that many of those attending will participate.

TECHNICAL SESSIONS

The objectives of the conference will be described by Doctor W. R. Clark (M '44) conference chairman. The need for improved vacuum tubes will be outlined by a number of representatives of instrument manufacturers and industrial users. The survey conducted by the Scientific Apparatus Makers of America concerning industrial uses for electron tubes will be discussed by one of their members.

The AIEE joint subcommittee on electron instruments, which is sponsoring this conference, will present the results of their survey conducted to determine the demand for special tubes for instrumentation. This survey has been conducted during the past year and has brought out many interesting angles on the special tube problem. The potential demand for improved tubes and the characteristics and tolerances which were requested by the tube users will be reported. The report will be published and advance copies may be obtained in advance of the conference.

Tube specifications now being formulated by the Joint Electron Tube Engineering Council will be discussed by V. M. Graham of this Council.

Programs of electron tube development and improvement projected by special user groups in other fields will be outlined. These groups include: commercial aviation companies; digital computer groups; the United States Navy, Army, and Air Forces; and the Bell System telephone companies. A summary will be made of the common objectives between these programs and the requirements indicated for the instrument field.

DINNER

A dinner for all those present will be held in the Crystal Ballroom of the Benjamin Franklin Hotel on Monday at 6:30 p.m. Dress will be informal. Doctor W. R. G. Baker (M '41) vice-president of the General Electric Company will be the principal after-dinner speaker. His subject will be "Manufacturers Policy with Relation to Special Tubes."

Following Doctor Baker's talk, representatives of several tube manufacturers will talk on the realization of improved electron tubes for instrumentation and industrial applications. The functional requirements that can be achieved will be related to practical design considerations. There will be a talk on the possible tolerances as affected by assembly and process control considerations. The economic aspect of manufacturing special tubes will be outlined and time will be allowed for discussion from those present of these problems.

CONFERENCE SESSION ON TUBE TYPES

The major portion of the program on Tuesday will be devoted to a round-table discussion of the several tube types which served as a guide in the electron tube survey. The session will lead off with a discussion of features common to several of the tube types, such as basing, envelope, and heater

Tentative Program

Conference on Electron Tubes, March 29–30, 1948

Monday, March 29

8:30 a.m. Registration

9:30 a.m. Session 1

Chairman: E. I. Green, Bell Telephone Laboratories (chairman, AIEE committee on instruments and measurements)

Objectives of Conference. *W. R. Clark* (chairman, AIEE subcommittee on electronic instruments) conference chairman

The Need for Improved Quality in Vacuum Tubes for Instrument and Industrial Use. *W. C. White*, General Electric Company; *C. T. Burke*, General Radio Company; *A. P. Upton*, Minneapolis-Honeywell Regulator Company; *H. F. Dart*, Westinghouse Electric Corporation; *F. B. Bramhall*, Western Union Company

The Survey Conducted by Scientific Apparatus Makers of America. *J. W. Harsch*, Scientific Apparatus Makers of America, recorder and controller section

The Survey Conducted by AIEE Joint Subcommittee on Electronic Instruments: Formulation and Circulation of Questionnaire. *H. R. Meahl*, General Electric Company

Method of Summarizing Replies. *Eric Isbister*, Sperry Gyroscope Company

Results of Questionnaire—A General Summary. *T. B. Perkins*, Radio Corporation of America

Results of Questionnaire—Unusual Requests. *G. N. Mahaffey*, Sylvania Electric Products, Inc.

2:00 p.m. Session 2

Chairman: H. Diamond, National Bureau of Standards

The Function and Aims of the Joint Electron Tube Engineering Council. *V. M. Graham*, Sylvania Electric Products, Inc. (chairman, Joint Electron Tube Engineering Council, Radio Manufacturers Association and Natural Electrical Manufacturers Association)

Current Programs of Electron Tube Development: Commercial Aviation. *H. C. Dyer*, Aeronautical Radio, Inc.

Digital Computers. *R. L. Snyder*, University of Pennsylvania

Navy. *J. W. Greer*, Bureau of Ships

Army. *J. E. Gorham*, Signal Corps

Air Force. *R. J. Framme*, Air Materiel Command

Bell System. *J. R. Wilson*, Bell Telephone Laboratories

Common Objectives in Electron Tube Development Programs. *A. Lederman*, Panel on Electron Tubes, Research and Development Board

6:30 p.m. Dinner Program

Chairman: Professor W. G. Dow, University of Michigan, (vice-chairman, AIEE committee on electronics)

Manufacturers Policy with Relation to Special Tubes. *W. R. G. Baker*. General Electric Company, (chairman, AIEE communication and science co-ordinating committee)

8:30 p.m. Session 3—After-Dinner Program

Chairman: W. G. Dow

Improved Electron Tubes for Instrumentation and Industrial Use:

Design Considerations. *N. H. Green*, Radio Corporation of America

Manufacturing Considerations. *N. L. Kiser*, Sylvania Electric Products, Inc.

Economic Considerations. *N. B. Krim*, Raytheon Manufacturing Company

Tuesday, March 30

9:00 a.m. Session 4—Open Forum on Electron Tubes for Instrumentation and Industrial Use

Chairman: D. G. Fink, *Electronics*

General Design Features—Basing, Envelopes, and so forth. *C. W. Martel*, Raytheon Manufacturing Company

Discussion will center around the following functional types. Discussion of each will be introduced by invited remarks from representative of tube manufacturer and member of AIEE joint subcommittee on electronic instruments.

Twin Diode

C. R. Knight, General Electric Company
D. B. Fisk, General Electric Company

Twin Triode—Medium Mu

C. M. Morris, Radio Corporation of America
C. C. Chambers, University of Pennsylvania

Twin Triode—High Mu

C. M. Morris, Radio Corporation of America
W. P. Wills, Brown Instrument Company

Pentode Voltage Amplifier

C. M. Morris, Radio Corporation of America
W. H. Tidd, Bell Telephone Laboratories

2:00 p.m. Session 5—Open Forum on Electron Tubes for Instrumentation and Industrial Use (continued)

Chairman: C. H. Willis, Princeton University (chairman, AIEE committee on electronics). Discussion will center around the following functional types. Discussion of each will be introduced by invited remarks from representative of tube manufacturer and member of AIEE joint subcommittee on electronic instruments.

Multigrid Converter

C. E. Coon, Tung-Sol Lamp Works Inc.
R. W. Slinkman, Sylvania Electric Products, Inc.
G. B. Hoadley, Polytechnic Institute of Brooklyn

Beam Power Tetrode

R. L. McCormack, Raytheon Manufacturing Company
E. R. Thomas, Consolidated Edison Company of New York, Inc.

Power Triode

R. L. McCormack, Raytheon Manufacturing Company
Rudolf Feldt, DuMont Laboratories

Power Rectifier

N. L. Kiser, Sylvania Electric Products, Inc.
A. H. Waynick, Pennsylvania State College

Gaseous Voltage Regulators

V. Ulrich, Hytron Radio and Electronics Corporation
A. J. Williams, Leeds and Northrup Company

Electrometer Tube

R. W. Slinkman, Sylvania Electric Products, Inc.
H. F. Dart, Westinghouse Electric Corporation

Miscellaneous Tubes

J. G. Reid, Jr., National Bureau of Standards

Conclusions of the Conference and Proposal of Resolutions. *W. R. Clark*, conference chairman

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rating. For each tube type there will be a short introductory talk by a member of the subcommittee accompanied by a lantern slide of the requirements for the tube as determined from the survey. This will be followed by discussion from the floor. This procedure will be followed for ten tube types.

At the Tuesday afternoon session the conference will be wound up with a short summary and the proposal of resolutions reflecting the consensus of opinion of the conference as to the further course of action which should be followed in the improved tube program.

LUNCHEONS

Informal luncheons at the hotel have been arranged by the committee for the convenience of those attending the conference, both for Monday and Tuesday noon. No program is contemplated at either luncheon. The luncheons will be $3 and reservations for the Monday luncheon must be made and paid for by March 15.

REGISTRATION AND RESERVATIONS

Registration for the conference should be in advance. For those planning to attend the dinner, reservations must be made and paid for by March 25. A card will be enclosed with the announcements of the conference for the convenience of those interested.

ELECTRON TUBE SURVEY REPORT

Preprints of the subcommittee report on the electron tube survey may be obtained by writing to C. C. Wilson at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. The report will be available about March 1. Price to AIEE members, $1; to nonmembers, $2.

ANNOUNCEMENTS

Announcements will be mailed to many representatives of instrument manufacturers, industrial laboratories, government agencies, and others who may be interested in this special tube program. No general mailing is contemplated to AIEE membership. Requests for announcements are invited and should be addressed to C. C. Wilson at AIEE headquarters.

AIEE Great Lakes District Meeting Set for Des Moines, April 1–3

Arrangements have been made for a 3-day meeting of the AIEE Great Lakes District to be held in Des Moines, Iowa, April 1–3, 1948, with headquarters in the Hotel Fort Des Moines. Six technical sessions will be held at which a number of papers will be presented covering a variety of subject matter: electronics, electric heating, network analysis and measurements, switchgear, a symposium on nucleonics, rotating machinery, heavy current busses, computer, and an optical radar for surveying. In addition, there will be a Student session at which papers will be presented by the Students. A banquet will be held on the first evening with a smoker and entertainment to be held on the second evening. Special entertainment has been arranged for the visiting women consisting of a tea, sight-seeing tour, and dinner.

INSPECTION TRIPS

Thursday afternoon inspection trips will be taken to the Firestone Tire and Rubber Company or the Iowa Power and Light Company. The Firestone Tire and Rubber Company plant is one of the most modern and streamlined of its type for the manufacture of large size tires and tubes for tractors, trucks, and earth-moving machinery. Its machines incorporate the latest practical controls and designs developed for the tire industry. The Iowa Power and Light Company main plant has a new 161-kv substation used to connect to the transmission line interconnecting Davenport, Des Moines, St. Joseph, and Kansas City. Modern transformers, switchgear, and carrier current equipment can be seen at this nearly completed project.

On Thursday afternoon a trip has been arranged to the Lake Shore Tire and Rubber Company or the Solar Aircraft Company. The Lake Shore Tire and Rubber Company is one of the largest industrial plants in Iowa. This modern new plant is devoted exclusively to the manufacture of passenger, truck, and tractor tires. The Solar Aircraft Company is one of the few plants in the United States working exclusively with stainless steel and process sheet steel to engine tolerances. The manufacture of high temperature parts for the new aircraft jet engine may be seen.

REGISTRATION AND RESERVATIONS

Members of District 5 and the nearby territory should register in advance by promptly filling in and mailing the advance registration card when received. This will assist the registration committee and save time on arrival. All members are requested to mention their attendance at the Great Lakes District meeting when writing to the Hotel Fort Des Moines, Des Moines, for reservations during the period of the meeting. The hotel then will give priority accordingly. A nonmember registration fee of $2 will be charged all nonmembers except enrolled Students, the immediate families of members, and local members of the Iowa Section.

Members are requested to make reservations at the Hotel Fort Des Moines, 10th and Walnut Streets, Des Moines, Iowa, early by writing directly to the hotel before March 15. Please indicate the type of reservation desired, and for twin bed and double rooms, the name of someone selected to join in occupancy. Room rates are:

Single	Double	Twin Beds
$3.25	$4.50	$7.00
3.50	5.00	8.00
4.00	5.50	8.50
4.50	6.00	
5.00	7.00	
6.00	8.00	
6.50	8.50	

Although arrangements have been made for sufficient rooms for the number expected, they will be held only if specifically reserved by those who will occupy them.

Tentative Program

AIEE Great Lakes District Meeting, April 1–3, 1948

Thursday, April 1

8:30 a.m. Registration

10:00 a.m. Opening General Meeting

R. F. Castner, presiding

Address of welcome. A. W. Brayton, secretary, Des Moines Chamber of Commerce

Remarks. T. G. LeClair, vice-president, AIEE Great Lakes District

Address. "Ceiling Unlimited," B. D. Hull, president, AIEE

2:00 p.m. Technical Session

48-101. A Practical Approach to Calculating Optimum Performance of Semiconductor Rectifiers. *E. D. Wilson,* Westinghouse Research Laboratories

48-102. Amalgam-Cathode Materials for Power Tubes. *J. A. M. Lyon, C. E. Williams,* Northwestern University

CP.* Induction Heating as a Practical Tool. *E. J. Rathsack,* Allis-Chalmers Manufacturing Company

CP.* Utility Experience with High-Frequency Heating. *H. R. Winemiller, H. Bunte,* Commonwealth Edison

2:00 p.m. Technical Session

48-103. The General Solution Method of Power Network Analysis. *L. A. Dunstan,* Federal Power Commission

48-104. Primary Detectors for Measurements. *E. E. Lynch, A. J. Corson,* General Electric Company

2:00 p.m. Inspection Trips

(*a*). Firestone Tire and Rubber Company

(*b*). Iowa Power and Light Company, main power plant and 161-kv substation

3:00–5:00 p.m. Women's Tea at the Wakonda Club

Transportation furnished

6:30 p.m. Informal Banquet—Women Welcome

Entertainment. Collins Radio Players

Speaker. (To be announced)

Friday, April 2

9:30 a.m. Student Technical Papers

9:30 a.m. Technical Session

48-106. A New Relayed Automatic Oil Circuit Recloser. *E. J. Casey, E. T. McCurry,* General Electric Company

48-107. Modern Design Conceptions Are Used to Make Improved High-Voltage Switches. *A. H. Powell, H. R. Harrison,* General Electric Company

48-108-ACO. Power Air Circuit Breakers in Metal-Clad Switchgear.** *R. C. Dickinson, B. I. Hayford,* Westinghouse Electric Corporation

12:15 p.m. Luncheon

Address. "Industrial Research and Development," Doctor J. F. D. Smith, dean of engineering, Iowa State College

1:30 p.m. Women's Sight-Seeing Tour

(Transportation furnished)

2:30 p.m. Symposium on Nucleonics

CP.* Cyclotrons. *J. B. Livingood,* Collins Radio Company

CP.* Synchrotrons. *H. C. Pollock,* General Electric Company

CP.* Nuclear Reactors. *A. Wattenberg,* Argonne National Laboratories

CP.* Radiation Measurements. *D. S. Martin,* Institute for Atomic Research

2:30 p.m. Inspection Trips

(*a*). Lake Shore Tire and Rubber Company

(*b*). Solar Aircraft Company

6:30 p.m. Smoker and Entertainment—Buffet Supper

6:30 p.m. Informal Women's Dinner Des Moines Club

By courtesy of the Iowa Power and Light Company

Saturday, April 3

9:30 a.m. Student Branch Counselors and Branch Representatives

9:30 a.m. Technical Session

CP.* Starting of Hermetically-Sealed Motors. *R. D. Fillmore,* University of Minnesota

48-109. Oscillographic Study of Synchronous Motor Hunting. *E. B. Kurtz,* University of Iowa

48-110. Progress Report on AIEE-ASME Standard Large 3,600-Rpm Turbine-Generators. *S. H. Mortensen,* Allis-Chalmers Manufacturing Company; *J. B. McClure,* General Electric Company; *C. M. Laffoon,* Westinghouse Electric Corporation

9:30 a.m. Technical Session

48-111. Experimental Determination of the Capacitances of Heavy-Current Busses Comprised of Solid or Tubular Rectangular Conductors. *R. D. Teasdale, T. J. Higgins,* Illinois Institute of Technology

48-112. A Large-Scale General-Purpose Electric Analog Computer. *E. L. Harder,* Westinghouse Electric Corporation; *G. D. McCann,* California Institute of Technology

48-113. An Optical Radar for Surveying. *W. W. Hansen,* Armour Research Foundation

12:30 p.m. Student Branch Luncheon

*CP: Conference paper; no advance copies are available; not intended for publication in *TRANSACTIONS.*

**ACO: Advance copies only available; not intended for publication in *TRANSACTIONS.*

—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

—ABSTRACTS of papers listed appear on pages 265–6 of this issue.

—PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in five-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the technical program committee ultimately will be published in PROCEEDINGS and TRANSACTIONS; essential substance of many will appear in ELECTRICAL ENGINEERING.

Iowa Power and Light Company, to be inspected on Thursday

Future AIEE Meetings

AIEE Conference on Electron Tubes for Instrumentation and Industrial Use
Benjamin Franklin Hotel, Philadelphia, Pa.
March 29–30, 1948

Great Lakes District Meeting
Des Moines, Iowa
April 1–3, 1948
(*Final date for submitting papers—closed*)

AIEE Conference on Electrical Engineering Aspects in the Rubber and Plastics Industries
Auditorium of M. O'Neil Company Department Store, Akron, Ohio
April, 1948

North Eastern District Meeting
New Haven, Conn.
April 28–30, 1948
(*Final date for submitting papers—closed*)

Summer General Meeting
Palace of Fine Arts, Mexico City, Mexico
June 21–25, 1948
(*Final date for submitting papers—closed*)

Pacific General Meeting
Spokane, Wash.
August 24–27, 1948
(*Final date for submitting papers—June 10*)

Middle Eastern District Meeting
Hotel Statler, Washington, D. C.
October 5–7, 1948
(*Final date for submitting papers—July 21*)

Midwest General Meeting
Schroeder Hotel, Milwaukee, Wis.
October 18–22, 1948
(*Final date for submitting papers—August 3*)

AIEE Conference on Electronic Aids to Medicine
New York, N. Y.
Fall, 1948

Southern District Meeting
Birmingham, Ala.
November 3–5, 1948
(*Final date for submitting papers—August 20*)

Winter General Meeting
Pennsylvania Hotel, New York, N. Y.
January 31–February 4, 1949

Summer Meeting Coupon. For the convenience of those interested in attending the 1948 summer general meeting in Mexico City, June 21–25, a "request-for-information" coupon has been provided on page 58A of the advertising section. The prompt return of this coupon, properly filled out, to AIEE Headquarters, 33 West 39th Street, New York 18, N. Y., will bring directly to the sender, hotel, transportation, excursion, or other information as desired.

Inspection Trips Planned for Summer General Meeting

AIEE members planning to attend the 1948 AIEE summer general meeting, to be held in Mexico City, June 21–25, are promised ample opportunity to visit some of the country's outstanding industries. The committee in charge of technical visits has succeeded in obtaining permission from the owners and managers of a number of large and important factories so that AIEE visitors may observe the progress that Mexico has made in recent years in the direction of industrialization.

Progress in industrialization of a country naturally is linked with power development, and one of the main objectives of Mexico's present administration is the electrification of Mexico. Among the power projects sponsored by the government, and possibly the most important one, is the hydroelectric system named for President Miguel Aleman, and constructed and operated by the Federal Electric Commission. Located at Ixtapantongo, a small village about 100 miles outside of Mexico City in the picturesque and rugged Bravo Valley, it now is providing much needed power for the nation's capital and nearby cities and towns serviced by the Mexican Light and Power Company, into the distribution lines of which the output of Ixtapantongo is fed.

Another plant which the AIEE will have an opportunity to visit is the one at Xotepingo, just a few miles outside of the capital, which provides the city with most of its water supply. Built by Mexican engineers a few years ago, it constitutes a definite contribution to the nation's economic welfare.

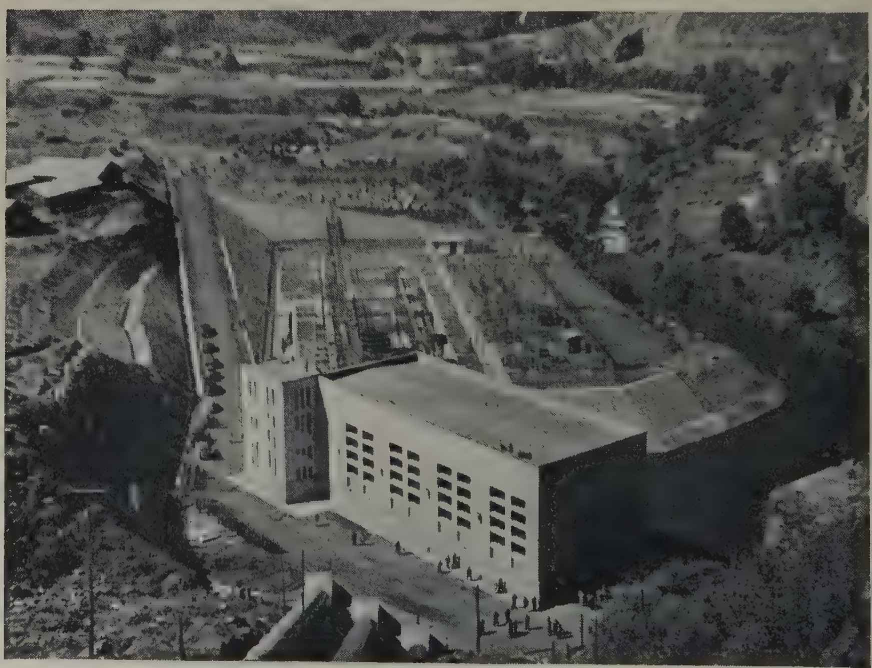
Antonio Ruiz Galindo, head of Mexico's Ministry of Economy, is also one of Mexico's leading industrialists. Owner of factories and hotels, his chief enterprise, the Distribuidora Mexicana, S. A., a steel furniture factory, is scheduled for inspection by AIEE visitors to the summer general meeting. Visits also are planned to La Consolidada, S. A., one of the largest steel and rolling mills in the country; to several important tire manufacturing plants such as Goodrich Euzkadi, Goodyear, and General Tire; to several large motion picture studios; to paper mills such as San Rafael y Anexas; and to Mexico's latest modern industry, the new factory at Tlalnepantla of Industria Electrica de Mexico, S. A., which, operating with Westinghouse patents, manufactures various domestic electric appliances, small motors, refrigerators, and the like. The Mexican Light and Power Company's plant at Necaxa and its substation at Nonoalco also may be inspected. All of the inspection trips are planned to balance the general technical program of the summer meeting.

Meeting on Electrical Problems in Rubber Industry Planned

The AIEE committee on general industry applications is planning to hold, in April, a 1-day general meeting in Akron, Ohio, devoted to electrical problems in the rubber industry. The arrangements for the meeting and the program are in the hands of the subcommittee on rubber and plastics industries, under the chairmanship of K. W. John (M '41) United States Rubber Company, Detroit, Mich.

The program will include papers and discussions on the problems of a-c power distribution, d-c spot conversion, motor

Aerial view of the power plant at Ixtapantongo, Mexico



enclosures and separate motor rooms, electric means of emergency stopping of rubber mills and calenders, classification of electric drive characteristics, and measurement methods.

The exact date and place of the meeting will be announced in a forthcoming issue of *ELECTRICAL ENGINEERING*. All engineers interested in the use of electric power in the rubber industry are invited to attend.

AIEE Forms Committee on Computing Devices

The board of directors, at its meeting in Pittsburgh on January 29, 1948, approved the formation of a new national technical committee on computing devices. The scope of this committee is

The treatment of all matters in which the dominant factors are the requirements, design, construction, selection, installation, and operation of machinery and devices relating to computing devices, including studies of the electromagnetic, electronic, and mechanical phenomena of such devices.

Fundamental mathematic, electronic, and properties of materials entering into these devices are not included.

The personnel of this new technical committee, as appointed by AIEE President B. D. Hull, are

Charles Concordia, *chairman*	W. C. Johnson
J. G. Brainerd	G. D. McCann
S. H. Caldwell	J. C. McPherson
E. L. Harder	J. D. Tebo

The new committee becomes a part of the communication and science group and its chairman becomes a member of the communication and science co-ordinating committee (*EE, Oct '47, p 1034*) of which Doctor W. R. G. Baker is chairman.

The formation of this committee increases the number of main technical committees of the Institute to 31.

Florida Branch Turns Tables

According to a recent edition of the *News Letter* of the Student Branch at the University of Florida, Gainesville, instead of the usual procedure of a Student Branch depending upon an AIEE Section for speakers on technical and other topics of current interest to engineers, this Student Branch has turned the tables and successfully taken the initiative in providing the Florida Section with a good program of papers prepared and presented by members of the Student Branch. The reported attendance at this Section meeting was 55.

Jointly arranged plans are underway for teams of members of the Student Branch to visit the various Subsections in Florida, presenting a program of papers prepared and arranged by the Students.

The Student Branch proudly reports also that its membership "already has broken all previous records."

Pacific Meeting Committee. Appointment of members of the general committee to make plans for the annual Pacific general meeting which is to be held in Spokane, Wash., August 24–27, 1948, recently was announced. Personnel of this committee will include: Richard McKay, *chairman;* H. C. Glaze, Jr., *vice-chairman;* H. Jack Reeves, *secretary;* T. Wendall MacLean, *treasurer;* W. H. Blankmeyer; J. L. Buckley; D. I. Cone; M. D. Duffy; H. M. Gustafson; D. R. Hoopes; G. E. Jenner; C. A. Poppino; W. C. Smith; H. D. Strong; C. F. Terrell. Committee chairmen are: H. B. Hodgins, *program;* N. H. Meyers, *hotel and registration;* Glenn George, *transportation and trips;* H. L. Vincent, *entertainment;* W. L. Thrailkill, *golf;* R. D. Sloan, *Student activities;* Hugh B. Tinling, *publicity;* W. W. Watkins, *finance;* Mrs. L. R. Gamble, *ladies' entertainment.*

North Eastern District to Meet in New Haven

A 3-day meeting of the AIEE North Eastern District will be held in New Haven, Conn., April 28–30, 1948. Headquarters for the meeting will be the Hotel Taft with the likelihood that some of the sessions will be held in the buildings of Yale University.

Arrangements are being made for a program of broad interest, consisting of seven technical sessions, and a student technical session, at which papers will be presented by the students and prizes will be awarded. In addition there will be a general session, which is planned to interest a great many members, and a District executive committee luncheon. Subjects for the technical sessions are as follows: power generation, transmission and distribution, transportation, relays, circuit breakers, communication and electronics, industrial applications, and miscellaneous.

The meeting also will afford an unusual opportunity to visit the various manufacturing plants in and about New Haven to see the electrical applications in the public utilities and factories. Because of conditions which prevail in New Haven, the committee recommends that it would be wise to make hotel reservations at the Hotel Taft as soon as possible and in advance of the receipt of the usual announcement of the meeting.

Official Nominees Announced for 1948–49

Everett S. Lee, engineer, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y., was nominated for the AIEE presidency for the year 1948–49 at the meeting of the nominating committee in New York, N. Y., January 29. Others named on the official ticket of candidates for the Institute offices that will become vacant August 1, 1948, are

For Vice-Presidents

Victor Seigfried, chief research engineer, electrical cable works, American Steel and Wire Company, Worcester, Mass. (North Eastern District, number 1).

John L. Callahan, research section head, RCA Laboratories Division, Radio Corporation of America, New York, N. Y. (New York City District, number 3).

Ira A. Terry, works engineer, General Electric Company, Fort Wayne, Ind. (Great Lakes District, number 5).

George N. Pingree, transformer specialist, General Electric Company, Dallas, Tex. (South West District, number 7).

Richard McKay, assistant general manager, The Washington Water Power Company, Spokane, Wash., (North West District, number 9).

For Directors

Clarence W. Fick, district manager, apparatus department, General Electric Company, Cleveland, Ohio.

Morris D. Hooven, electrical engineer, electric engineering department, Public Service Electric and Gas Company, Newark, N. J.

F. O. McMillan, head, electrical engineering department, Oregon State College, Corvallis, Oreg.

For Treasurer

W. I. Slichter, professor emeritus, electrical engineering, Columbia University, New York, N. Y.

The nominating committee, in accordance with the constitution and bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the board of directors from its own membership.

The constitution and bylaws of the Institute require publication in *ELECTRICAL ENGINEERING* of the nominations made by the nominating committee. Provision is made for independent nominations as indicated in the following excerpts from the constitution and bylaws:

Constitution

Section 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District covered.

Bylaws

Section 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (Constitution), must be received by the secretary of the nominating committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the nominating committee in accordance with article VI of the Constitution and sent by the secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

BIOGRAPHICAL SKETCHES OF NOMINEES

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "Personal" columns of the April issue.

Winter Meeting's 51 Technical Sessions Draw Heavy Attendance at Pittsburgh

When plans were announced a year ago for the holding of the 1948 AIEE winter general meeting in Pittsburgh, many and diverse were the estimates of probable attendance, estimates ranging all the way from 1,000 to a "optimistic" 2,500. The final verified registration figure was and might have been even greater if more people had been able to obtain hotel accommodations. Official headquarters for the meeting were on the 17th floor of the William Penn Hotel where a variety of meeting rooms and halls provided facilities for a continuous succession of parallel committee, technical, and conference sessions. This was the second time since 1924 that the AIEE's big winter meeting has been held outside the city of New York, it having been held in Philadelphia in 1924 and again in 1941. The 1949 winter general meeting is scheduled again to be held in New York City.

The scope and variety of subject matter offered set a new high record for AIEE general meetings. A total of 51 regularly scheduled technical sessions included 18 at which only formal technical program papers were presented and discussed, 18 at which only informal conference papers were presented and discussed, and 15 which accommodated both types of papers grouped according to relationship of subject matter. At these sessions, a total of 106 formal technical program papers and 117 conference papers were presented and variously discussed. According to plan, the Pittsburgh program offered a pronounced industrial flavor throughout almost its whole range of subject matter from research and new materials to a variety of industrial applications and some specific industrial problems. Some 13 sessions were devoted to one phase or another of power transmission and distribution problems, blending closely into the dozen sessions which featured various more or less specific industrial applications and power-utilization problems. Electronics and applications of electronic equipment accounted for five sessions, and another five were devoted to research, new materials, and basic sciences. Rail transportation, and light and heavy traction subjects accounted for three sessions; communications topics, four sessions; miscellaneous electric equipment, three sessions; power generation, two heavy sessions. Machine tools, nucleonics, heat-pump house heating, and safety subjects also accounted for a session apiece during the meeting.

Analysis of Verified Registration at Recent Winter Meetings

District	1944	1945	1946	1947	1948
Middle Eastern (2)......	474..	463..	645..	747..	1,912
North Eastern (1).........	301..	278..	474..	627..	367
Great Lakes (5).........	131..	153..	200..	300..	293
New York (3)..	608..	704..	1,123..	1,577..	227
Southern (4)...	80..	40..	65..	118..	108
Canada (10)...	29..	41..	52..	78..	73
South West (7).	21..	32..	38..	41..	61
Pacific (8).....	4..	3..	13..	24..	17
North West (9).	6..	3..	7..	10..	11
North Central (6).........	4..	1..	7..	5..	6
Foreign...........................				40..	6
Totals.......	1,658..	1,718..	2,624..	3,567..	3,081

An all-day meeting of the board of directors and some 75 or more scheduled and spontaneous meetings of AIEE administrative and technical committees were given over to a variety of detailed problems incidental to AIEE planning and operation. These various activities are reported briefly on the following news pages of this issue, or will be reported in subsequent issues of *ELECTRICAL ENGINEERING* as the various committees make appropriate activity reports available for publication.

The highlights of the various technical sessions are reported briefly in the following pages.

EDISON MEDAL PRESENTED

At a general session Wednesday morning, President Blake D. Hull, acting for the Institute, presented the 1947 AIEE Edison Medal to Doctor Joseph Slepian (F '27) of the Pittsburgh Section. Doctor Slepian is associate director of the Westinghouse Research Laboratories, and received the 1947 Edison Medal for "his practical and theoretical contributions to power systems through circuit analysis, arc control, and current interruption." Doctor Slepian becomes the 37th distinguished electrical engineer to win this coveted award which is given in recognition of "meritorious achievement in electrical science."

M. W. Smith (F '42) Westinghouse vice-president in charge of engineering, presented a biographical outline of the career of the medalist. The history and significance of the Edison Medal were reviewed on behalf of Chairman S. M. Dean of the AIEE Edison Medal committee by James F. Fairman of the New York Section, AIEE director and past vice-president.

The full texts of the formal addresses delivered at the Edison Medal ceremonies are given elsewhere in this issue of *ELECTRICAL ENGINEERING*.

ENTERTAINMENT

The twin major features of the entertainment program were the annual smoker and the dinner-dance, which were held respectively Tuesday evening and Wednesday evening in the William Penn Hotel. Paralleling the men's dinner-smoker Tuesday evening was an informal dinner gathering and evening program arranged for the women guests and held in the Pittsburgh room of the William Penn Hotel. In addition to this latter item, the unusually generous program of social and entertainment events for women guests included a

Analysis of Registration at 1947 Winter General Meeting

		Districts											
Classification	Pittsburgh	2*	1	3	4	5	6	7	8	9	10	Foreign	Totals
Members............	427	489	253	165	79	240	5	44	15	11	53	3	1,784
Men guests..........	480	306	87	47	17	39	1	12	2	0	13	3	1,007
Women guests.......	87	53	20	12	6	12	0	4	0	0	6	0	200
Student members....	48	22	7	3	6	2	0	1	0	0	1	0	90
Totals............	1,042	870	367	227	108	293	6	61	17	11	73	6	3,081

* Outside of Pittsburgh Section territory.

AIEE PROCEEDINGS

Order forms for AIEE *PROCEEDINGS*, and abstracts of the papers included, have been published in *ELECTRICAL ENGINEERING* as listed below. Each section of *PROCEEDINGS* contains the full, formal text of a technical paper including discussion if any, as it will appear in the annual volume of *TRANSACTIONS*. *PROCEEDINGS* are issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 576–8; Jan '47, pp 82–3*), and are available to AIEE Associates, Members, and Fellows.

Meetings	Abstracts	PROCEEDINGS Order Forms
Winter	Jan '47, pp 84–93; Feb '47, pp 190–1	Feb '47, pp 33A and 34A
North Eastern District	Apr '47, pp 401–02	June '47, pp 55A and 56A
Summer General	June '47, pp 607–14; July '47, p 708	June '47, pp 55A and 56A
Pacific General	Aug '47, pp 840–2	Dec '47, pp 55A and 56A
Middle Eastern District	Sept '47, pp 925–7	Dec '47, pp 55A and 56A
Midwest General	Nov '47, pp 1125–8	Dec '47, pp 55A and 56A

get-acquainted tea Monday afternoon, an extensive sight-seeing tour and luncheon at the Twentieth Century Club Wednesday, a trip to the H. J. Heinz plant Thursday, and other short tours to points of interests in and near this city arranged for interested groups, in addition to facilities for bridge and informal social hours at the commodious women's headquarters suite at the William Penn Hotel.

Also related to the winter meeting entertainment program was the annual Eta Kappa Nu smoker-dinner at the William Penn Hotel Monday evening, which featured recognition awards to outstanding young electrical engineers. This activity is reported in some detail elsewhere in this issue.

INSPECTION TRIPS

A generous variety of inspection trips, well correlated with the technical subjects covered by many of the technical sessions, was provided. These included the following:

1. The Irvin Works of United States Steel's Carnegie-Illinois Steel Corporation, about 13 miles southeast of downtown Pittsburgh. There are four main divisions of this installation, an 80-inch continuous hot-strip mill for the production of coils and sheets, a tin- and black-plate division, a sheet-finishing department, and a tin-finishing department. Electrical operation prevails throughout, the 42,250-horsepower main driving motors for the hot-mill being reputedly the largest such application to date.

2. The new cyclotron at the University of Pittsburgh' recently put into operation in the radiation laboratory there, and capable of delivering alpha particles at 34,000,000 electron volts, or heavy hydrogen atoms at 17,000,000 electron volts.

3. The East Pittsburgh Works of the Westinghouse Electric Corporation, where the inspection started with a demonstration at the high power laboratory with interrupting tests at 345 kv on a circuit breaker, and continued through various manufacturing aisles.

4. The Dravo Corporation Shipyard on Neville Island, 11 miles down the river from the Pittsburgh "Point," where the construction of all-weld ships, and the construction of a variety of material-handling equipment was viewed.

5. The 10,000-kva 66-kv series capacitor installation of the Duquesne Lighting Company at its Kennedy substation, directly related to technical papers on the program.

6. The Aluminum Research Laboratories of the Aluminum Company of America at New Kensington, where a variety of research activities was inspected.

7. The Central Experimental Station of the United States Bureau of Mines at Bruceton about 12 miles south of Pittsburgh. In addition to offices, laboratories, and warehouses maintained in the city, an experimental drift mine with about 2 miles of passageways is maintained at Bruceton where explosives, blasting devices, electric and other equipment are developed and tested.

8. The Tidd 500-kv test project at Brilliant, Ohio, about 50 miles west of Pittsburgh, which has been described in previous issues of *ELECTRICAL ENGINEERING*.

9. The Copperweld Steel Company's plant at Glassport afforded an opportunity for visitors to observe the manufacture of copper-covered steel products as made by the Molten-Welding process in "the only mill of its kind in the world."

10. The Ford City plant of the Pittsburgh Plate Glass Company, where both the pot-testing and the continuous-ribbon-rolling methods were available for inspection along with finishing processes and equipment.

11. Springdale power station of the West Penn Power Company about 20 miles up the Allegheny River from Pittsburgh, a station first placed in service in 1920 and enlarged in 1946 to its present capacity of 337,000 kw gross. Some 3,500 tons per day of coal is supplied to this plant from a subsidiary coal company located on the opposite side of the river.

12. In addition to the foregoing formally organized inspection trips, the following companies also provided for the accommodation of inspection groups: Allis-Chalmers Manufacturing Company, N. W., Pittsburgh, Pa.; Elliott Company, Jeannette, Pa.; Pennsylvania Transformer Company, Canonsburg, Pa.; Railway and Industrial Engineering Corporation, Greensburg, Pa.; Union Switch and Signal Company, Swissvale, Pittsburgh, Pa.; Westinghouse Electric Corporation—Transformer Division, Sharon, Pa.; Edwin L. Wiegand Company.

COMMITTEE ACTIVITIES

Some 75 or more technical and administrative committees held one or more business sessions during the week; the board of directors also held its regular winter meeting. The highlights of these various meetings are reported elsewhere in these pages or will be reported in future issues if and as appropriate reports are made available for publication.

WORKING COMMITTEES

The personnel of the various working committees responsible for the success of the winter meeting include the following:

General Committee: C. A. Powel, *chairman;* C. T. Sinclair, *vice-chairman;* L. N. Grier, *secretary-treasurer;* H. S. Fitch; Paul Frederick; J. R. MacGregor; A. C. Monteith.

Finance Committee: R. L. Dunlap, *chairman;* E. W. Aestereich; W. A. Furst; L. N. Grier; H. A. P. Langstafl; G. W. Penney.

Meetings and Papers: R. C. Gorham, *chairman;* F. S. Brown; H. E. Chisholm; C. B. Downer; L. H. Hemeter.

Registration and Information: B. M. Jones, *chairman;* J. W. Batchelor; W. C. Bowen; C. N. Clark; G. B. Dodds; C. V. Fields; C. H. Jensen; F. D. Marston; E. S. Reeser; F. E. Reiber; H. H. Wagner.

Inspection and Transportation: A. A. Johnson, *chairman;* W. A. Albert; E. W. Brewer; F. W. Cramer; H. M. Foss; V. E. Hill; C. A. Jensen; C. L. Jordan; H. H. Marsh; N. A. Mowry; George Phillips; B. E. Rector.

Publicity: M. Getting, Jr., *chairman;* D. L. Hemenway; C. F. Nagel; R. J. Salsbury.

Hotels: C. M. Skooglund, *chairman;* J. A. Cadwallader; R. J. Weber.

Entertainment: M. S. Angier, *chairman;* J. P. Barton; J. S. Brown; R. B. Fulton; L. E. Hemeter; R. C. McKee; L. E. Olmstead; W. H. Osterle; M. E. Reagan.

Women's Entertainment: Mrs. G. A. Price, *chairman;* Mrs. R. L. Dunlap; Mrs. H. S. Fitch; Mrs. Paul Frederick; Mrs. M. Getting; Mrs. R. C. Gorham; Mrs. L. N. Grier; Mrs. A. A. Johnson; Mrs. B. M. Jones; Mrs. J. R. MacGregor; Mrs. C. T. Sinclair; Mrs. C. M. Skooglund.

Electronic and Resistance Welding Are Subject of First Technical Session

The first technical session of the 1948 AIEE winter general meeting in Pittsburgh, Pa., on January 26, was devoted to a discussion of electronic and resistance welding. This session was under the chairmanship of G. W. Scott, Jr. (M '45) Armstrong Cork Company, Lancaster, Pa.

MEASUREMENT OF INTERFERENCE

"Measurement of Interference from Radio-Frequency Heating Equipment," was the subject of a paper by George H. Brown (M '41) Radio Corporation of America, Princeton, N. J.

This paper establishes some of the basic relationships pertinent to radiation from high-frequency sources and by means of measurements on typical radio-frequency equipment shows how practical data may be related to theoretical contributions. The equations for high-frequency propagation are extended by means of the van der Pol relation to the low-frequency case. That is, the frequency ranges usually used for induction heating the near fields of radiating loops at low frequencies are studied theoretically and the relationships are verified by observation of a typical induction heating unit.

SHIELDING

"Shielding of Electronic Generators," was discussed by G. W. Klingaman, Radio Corporation of America, Camden, N. J. This paper brought out the fact that stray radio-frequency currents in the vicinity of a high-frequency heating installation produce local effects which may burn out protective devices and cause injury to operators. They also may produce interference with communication circuits. The ways in which such conditions can occur are numerous. As an example, current flowing in a ground return circuit between a generator and its applicator will develop a potential difference between the two units. This causes currents to flow on the surfaces of attached conductors, water pipes, or electric conduits. These stray currents may encounter considerable radiation resistance and thus produce interference.

Location of conductors carrying radio-frequency currents is done best with a small current probe, which is essentially a tuned circuit and detector. Measurement of radiated interference is possible with a field intensity meter which may be moved about the installation at a fixed distance so that a polar plot of the intensity can be made.

Radiation increases with increasing current or voltage, conductor dimensions, and generator frequency. With moderate precautions, it is not serious at low frequencies. At higher frequencies units must be shielded completely, with no gaps or poor joints which allow high-frequency power to leak into undesired paths. Shielding should be made of a good conductor, although wire screen may be used if the mesh is small. Doors should be constructed with contacting fingers along their periphery, and windows should be screened. Entrances for admitting the work to an enclosure may be protected with ducts, if they are to be left open.

Transmission lines of the concentric type are preferable. All wires entering the units either should be shielded completely by conduit or filtered at the point where they are led into the equipment.

Radiation from most low-frequency generators in the range 10 to 500 kc is low. Under certain conditions, however, fields of the order of 50 to 100 microvolts per meter at a mile distance have been observed. From 2 to 200 megacycles field intensities between 100 and 1,000 microvolts are possible. The problem of shielding in the range 200 to 30,000 megacycles is difficult and fields are sometimes as high as 1,000 to 5,000 microvolts at a mile.

By careful shielding, reductions of 50 to 100 decibels from the foregoing intensities have been obtained in test installations.

DIATHERMY DESIGN

"Federal Communications Commission Diathermy Design for Low-Harmonic Radiation and Good Frequency Stability" (48-10), E. W. Chapin, W. K. Roberts, and M. C. Mobley, Jr., all of the Federal Communications Commission, Laurel, Md., was presented.

In June 1947, FCC issued rules governing high-frequency and industrial heating in an effort to eliminate interference with radio, television, and other communication channels. To prove the practicability of the rules, a diathermy machine was designed, built, and tested by the FCC laboratory. Frequency variation was limited to 12-kc load variations and 56 kc when operated continuously into a fixed full load, based upon 27.320 megacycles. By careful design, adequate shielding, and scientifically designed coupling units and power filters, the harmonic radiation was limited to an acceptable value. This machine was not intended as a prototype for a commercial manufacturer, but rather an indication of what could be done in the field of high-frequency heating.

ECONOMIC ASPECTS

A new approach to induction heating design problems was introduced by Lawrence M. Duryee (M '42) in his presentation of his paper "Some Economic Aspects of Radio-Frequency Heating" (48-17). Equations were derived for determining the economies of using capacitors to supply reactive power for induction installation, frequency selection, and coupling methods, Specific application examples were given of induction and dielectric heating in various frequency ranges. Equations for dielectric heating speed were derived, and methods given for calculating the economies of vacuum tube oscillators.

INDUSTRIAL USES

"Industrial Electric Resistance Heating," a paper by Lee P. Hynes (F '43) Hynes Electric Heating Company, Camden, also was presented at this session and is summarized in the following.

Among the advantages of resistance heating are its inherent efficiency of almost 100 per cent in converting electric power into heat energy, high thermal efficiency in transferring this heat to the work, adaptability to the standard commercial power circuits without expensive transformers, moderate investment cost, and reliable service.

Resistance heating elements are made of a size, shape, and construction to suit the use for which they are intended. By far the greatest number have heat producing resistors of nickel chrome alloy wire or ribbon. Electric current flowing through this high resistance metal creates heat. Refractory insulation is used to insulate electrically and support the heated resistor. This insulation must have ample dielectric strength at the maximum operating temperature. Some heating elements have resistors embedded in compressed refractory powder, with a metal sheath enclosure, carrying suitable insulated terminals for the power supply. Enclosed elements of this kind depend to a large extent on conduction for delivering their heat.

Heavy duty heating elements often have resistors of wire or ribbon supported by preformed refractory insulators flexibly mounted to withstand shock and permit free expansion and contraction. Open elements of this kind permit heavy loading and can operate at high temperatures as they deliver most of their heat by radiation. They are well suited for grouping into large assemblies with substantial bus connections. This construction permits clearances to ground ample for the higher commercial voltages, even at elevated temperatures. When inserted into tubes they form pressure-type units of large heating area.

The more important uses of resistance electric heating are in industrial process equipment where careful engineering design and sound experience have produced highly efficient and reliable results. Some typical examples are heat treating furnaces; hot air recirculating dryers; electric boilers for steam, hot water, dowtherm, and so forth; hot oil heat transfer systems; preheaters for fuel oil; ovens; electric unit air heaters; electric catalysts; steam superheaters; ice melters; air duct heaters; radiant heaters; and tanks or kettles for pitch, oil, wax, and chemicals. Many engineers are so used to thinking in terms of steam that they fail to realize the basic differences between steam and electric heating. With steam there is an initial accelerated input of heat when the work is cold as a result of the high rate of steam condensation. As the temperature rises this condensation rate drops and heat transfer falls in proportion because the heat gradient drops. With electric heat the energy input is practically constant and temperatures rise at a nearly uniform rate because the heat gradient remains substantially constant. It must be remembered that the temperature of an electric heater rises as the ambient temperature surrounding it rises. The heat density rating of an electric heater must be designed for its maximum temperature when operating at the maximum ambient temperature. Wherever any change of energy input from an electric heater is required, some change of the power input must be made by suitable control means. This may be accomplished in several ways such as change in impressed voltage, change in the number of heater sections in operation, or by time cycling.

Also presented was "Simple Means for the Prediction of Generator Performance in Induction Heating," by Eugene Mittelmann, consulting engineer and physicist.

Session Devoted to Steel Industry Applications

Applications in the steel industry was the subject of a technical session on Monday morning, January 26, of the AIEE winter general meeting in Pittsburgh. F. W. Cramer (M '40) Carnegie-Illinois Steel Company, Pittsburgh, Pa., and J. D. Leitch (M '42) Electric Controller and Manufacturing Company, Cleveland, Ohio, presided.

PINHOLE DETECTORS

"Pinhole Detectors for the Steel Industry," was the title of a paper by M. D. Bassett and L. U. C. Kelling (A '42) General Electric Company, Schenectady, N. Y. Pinhole detectors are used by the steel industry to detect and identify the location of pinholes occurring in steel strip used for tin plate. This equipment consistently can detect and locate pinholes as small as 0.005 inch in diameter in a steel strip which is moving at a speed of 1,000 feet per minute. The steel strip passes through a scanner which projects a curtain of light across the width of the strip. A pinhole passing through this lighted area permits a small amount of light to fall upon one or more of a group of photoelectric tubes located beneath the strip. The signal thus formed is amplified greatly and transmitted to a control panel where a time delay is introduced. The signal then is passed on to a marking device which produces a distinctive pattern upon the surface of the strip.

The timer which is incorporated in the control panel is a very important part of this equipment as it assures that the mark appears adjacent to the pinhole over a wide range of strip speeds. The marker has a fixed operating time, this being the time from the instant the marker is operated until it actually marks the strip. It is therefore necessary to operate the marker before the pinhole arrives at the position of the marker. As the marker is located at some distance from the scanner, a time delay must occur between the time the pinhole is detected and the time the marker is operated. To insure that the mark will be adjacent to the pinhole at all strip speeds, this time interval must be a direct function of scanner to marker distance and an inverse function of strip speed, minus the fixed marker operating time. The required time delay is obtained by charging a capacitor with a constant current which is proportional

to strip speed, the value of this current being determined by the voltage delivered by a tachometer generator which is driven by the line and whose voltage is therefore proportional to strip speed. The circuit arrangement is such that the time delay produced is a direct function of scanner to marker distance and an inverse function of strip speed, minus the fixed marker operating time. Provision is made on the control panel for adjustment of the fixed time to compensate for the slight difference in operating time of various markers and for adjustment of the variable time to compensate for various scanner to marker distances.

THICKNESS GAUGE

Another continuous noncontacting gauge, the "X-Ray Thickness Gauge for Cold Rolled Strip Steel" (48-14), was described by W. N. Lundahl (Membership Application Pending) of the Westinghouse Electric Corporation, Baltimore, Md. X-ray gauging is accomplished by irradiating the material under test and, in a sense, measuring the drop in radiation intensity through that material. The receiving unit which was found to have the highest accuracy and most reliability is composed of a fluorescent screen (such as zinc-cadmium sulphide) which absorbs the high energy X rays that pass through the test material and emit visible light. This light actuates a photoelectric multiplier tube in proportion to its intensity. Hence the output of the photoelectric tube is a measure of the thickness of the material through which the X rays passed. To avoid drifts and cumulative inaccuracies, it was found necessary to use two X-ray sources, one to irradiate the test material and another to be used for comparison purposes by irradiation of a standard sheet. The results of the two X-ray signals are compared to give a final result by a single photoelectric multiplier pickup. Stabilization of the pickup element is accomplished with auxiliary electronic circuits.

X-RAY THICKNESS GAUGE

The closing paper of the session, "An X-Ray Thickness Gauge for Hot-Strip Rolling Mills" (48-100), by C. W. Clapp and R. V. Pohl (Membership Application Pending) of the General Electric Company, Schenectady, N. Y., described one of the developments using X rays for measurement of thickness. The need in the steel industry for a continuous gauging device operating without direct contact with the test material, and the numerous applications of such a gauge tester, prompted research and development of an X-ray thickness gauge. Two X-ray beams from a single source are used. The reference beam passes first through a wedge of absorbing material, which has been set for the nominal thickness desired, and falls upon a radiation detector. Here the signal, which is a measure of the X rays not absorbed by the wedge—and therefore of the wedge thickness—is compared with a standard reference intensity and the result is used to control an electronic voltage regulator in the primary circuit of the X-ray tube supply voltage. The measuring beam passes through a "measuring" wedge of absorbing material and the steel to be measured before falling on its radiation detector. Again the signal is compared with a standard reference signal and the result is used to control a motor which moves the measuring wedge until the two signals are equal. Hence the thickness of the unknown steel sample is the difference between the effective thicknesses of the wedges in the reference and measuring circuits. The radiation detector uses silver-activated zinc-sulphide phosphor to absorb the X rays and emit light which, in turn, falls upon a multiplier-photoelectric tube. The standard reference signals are obtained from glow discharge lamps and the comparison circuits are electronic.

Relays Are Subject of Monday Session

W. R. Brownlee (M '38) Commonwealth and Southern Corporation, Jackson, Mich., presided over a session on Monday, January 26, at which three papers on relays were presented.

BIBLIOGRAPHY

"Bibliography of Relay Literature 1944–46," prepared by the project committee on relay bibliography of the AIEE relay committee was presented by title. Articles appearing in AIEE *TRANSACTIONS*, *ELECTRICAL ENGINEERING*, and most of the chief technical publications of the world, are indexed by subject. This interim report was released to make the information available to the entire industry before the publication of the next 10-year report.

RELAYING DIFFICULTIES

Surprising discoveries of interest to the entire electric power engineering field were described in the paper "Relaying Difficulties Disclosed by Staged Fault Tests" (48-12), by W. A. Morgan (M '42) and Byron Evans (M '47), both of the Bureau of Reclamation, Denver, Colo. To check the operation of 20-cycle reclosing circuit breakers on a newly installed parallel tie-line between Parker and Phoenix, Ariz., fault tests were staged early in February 1947. It was found that, despite careful design, residual transient current in the current transformers when the 161-kv lines were energized was sufficient to operate the carrier-current ground-trip element on occasions, that contact bounce was experienced in the carrier ground relay element, that two of the directional ground relay polarizing current transformers were incorrect, that there were defects in the carrier-control relay circuits, and that inadequate backup protection had been provided. Data also were taken to determine the optimum value of the resistance paralleling the main circuit breaker contacts and the time consumed while ionized arc gases move upward or disperse. Corrective measures were taken and another set of tests staged, which proved the adequacy of the corrections.

The membership committee meeting in Pittsburgh

SERVICE RESTORATION

"Simplicity is the keynote of reliable power service," said Kenneth N. Reardon (M '45) of the West Penn Power Company, Pittsburgh, Pa., in his presentation of "Service Restoration with Automatic Airbreak Switches" (48-13). By-pass, grounding, isolating, and sectionalizing functions can be performed by automatic air break switch installations. Such an installation consists of four components: a means of detecting that a service abnormally exists (potential transformers or power transformers), a relay sequence control scheme (time delay overvoltage and undervoltage relays combined with an operation lock-out relay and latch-type selector relay), a source of power for operating the air switches (a storage battery or a single-phase transformer), and the air break switch itself. Control, sequence, and operation of transfer and sectionalizing installations were given by the author.

Several Instruments Discussed at Radiation Measurement Session

A number of different types of instruments were described at the Monday morning session on instruments for radiation measurement which was held during the AIEE winter general meeting in Pittsburgh, Pa. Five conference papers were presented at the session which was presided over by G. W. Dunlap (M '42) General Electric Company, Schenectady, N. Y.

CRYSTAL COUNTERS

"Crystal Counters," was the subject of a conference paper by R. Hofstader and K. A. Yamakawa (A '43), both of Princeton University, Princeton, N. J. After a brief introductory talk on the general subject of crystal counters, the results of a recent investigation of the use of silver bromide for crystal counters were presented. Besides establishing that silver bromide is another material which can be used as a counter, several facts have been uncovered which help in understanding hitherto unexplained behavior observed in silver-chloride counters. The counting with silver bromide all has been done at −196-degrees centigrade. The silver bromide crystals have been grown in the laboratory by Mr. Yamakawa. Some of the observed facts mentioned are

1. A sample of silver bromide prepared from the solidified crystal in a single crystallization process, counted at low temperatures. Above 500 volts per centimeter many counts were observed without a source present. These counts are caused by d-c conduction.

2. In crystallizing from the melt, it is well known that purification (by foreign-ion rejection) of the main component takes place. It has been observed that the purification process in silver bromide during crystallization is very striking, judging by the color of the samples. Pure materials are much lighter in color than impure ones and much more transparent. Pure samples have been developed from chemically pure grade material by repeated crystallization. After two crystallization processes an attempt was made to look for counts in a sample cut from the solidified crystal.

3. A crystal about three-eighths of an inch in diameter and six millimeters thick, taken from the solidified crystal, was placed in the apparatus. When cooled to low temperatures no counts were observed above noise. The interpretation of this behavior is that the crystal was highly strained. This was confirmed by observation through crossed Nicols prisms.

4. The same crystal was left in position and annealed in a vacuum from 330 degrees centigrade to room temperature. Then it was brought down further to minus 196 degrees centigrade. The crystal then showed counts due to RaC gamma rays, the largest of which were about five times the noise level of a model 501 amplifier. No d-c conductivity or spurious pulses without source were observed until the voltage gradient was about 7,000 volts per centimeter. The interpretation of the relative absence of spurious pulses is that the material is pure. This is consistent with the work of Koch and Wagner.

5. The crystal was left in position and annealed in vacuum from 380 degrees centigrade to room temperature. Then it was cooled slowly to minus 196 degrees centigrade. Counts were observed, caused by RaC gamma rays, the largest of which were 16 times the noise level of the amplifier.

6. Repeated warmings and coolings of the crystal, in the same position, reduced the same of the largest pulses. It is therefore evident that the annealing is very important in determining pulse size.

7. When this crystal has counted a large number of pulses, the pulse height decreases because of polarization of the medium. This has been observed by other investigators (Street, Wouters, and others). Spurious pulses have been observed after counting about 100,000 gamma rays. This is consistent with the work of Lehfeldt in 1935 and the observations of Hofstadter (1947) in thallium bromide and thallium iodide.

8. Most rise times are in the neighborhood of a microsecond or less at 5,000 volts per centimeter.

Mr. Yamakawa plans to make a careful study of the rise times (mobility) and pulse sizes in silver bromide by photographic techniques.

L. F. Curtiss, National Bureau of Standards, Washington, D. C., presented a paper called "Geiger-Müller Counters." The construction and simple theory of the mode of operation of Geiger-Müller counters was discussed. References were made to associated electronic circuits used to observe the pulses from these counters in radiation measurements. Descriptions were given of special modifications in the construction of counters for particular applications. One is a needle counter with a barrel 0.8 millimeter in diameter for use when a gamma-ray counter of small volume is required. The other is a thin-walled beta-ray counter made from a commercial toothpaste tube. The presentation was intended for those who had little or no previous experience with Geiger-Müller counters.

The remaining three conference papers that were presented at the session were "High-Speed Counters," by J. L. Lawson, General Electric Company; "Photomultiplers," by J. W. Coltman, Westinghouse Electric Corporation; and "Vibrating Reed Electrometer," by H. Forstat, Argonne Laboratories.

Variety of Subjects Covered at the Symposium on New Materials

Featuring a program of 14 conference papers, the Monday morning symposium on new materials covered a variety of subjects including dielectrics, insulation, and semiconductors. Chairman at the session was C. G. Suits (F '46) of the General Electric Company, Schenectady, N. Y.

"FERROXCUBES"

"Magnetic Oxides," were discussed by F. G. Brockman of Philips Laboratories, Inc. According to Mr. Brockman a new development in soft ferromagnetic materials has been the outcome of research carried out by Snoek, Verwey, and coworkers in the Eindhoven, Holland, Laboratories of the N. V. Philips Gloeilampenfabrieken. The materials are mixtures in the form of solid solutions of various ferrites. The ferrites are chemical compounds of the general formula MFe_2O_4 where M is a bivalent metal. As is typical of chemical compounds, the electrons are bound by valence forces and therefore the electrical resistivity of these new materials is very large as compared with the magnetic metals and alloys. Because of this high resistivity (from 10^7 to 10^{12} times that of iron) eddy current losses are very small. The trade name "Ferroxcube" is used to designate these materials and, although there are numerous varieties in the developmental stage, there is now one in limited production. This one is referred to as "Ferroxcube III" and the characteristics typical of current production are

Initial permeability, μ_0, 1,000 to 1,500
Losses, at 60 kc, $\tan \delta/\mu$, 0.08 to 0.12×10^{-4}
Hysteresis coefficient, at 2 kc, a, 2 to 5×10^{-6}

In these data the quantity $\tan \delta/\mu$ is the phase angle between B and H divided by permeability. It is related to the quantity $R/\mu fL$ used by Legg ("Magnetic Measurements at Low Flux Densities Using the A-C Bridge," *Bell System Technical Journal*, 1936), by the relationship:

$$\frac{\tan \delta}{\mu} = \frac{1}{2\pi} \frac{R}{\mu f L}$$

The hysteresis coefficient a is that used by Legg. That the characteristics of Ferroxcube III will improve as production experience grows is indicated by the superior qualities of laboratory samples. Continuing development of other varieties of Ferroxcubes can be expected to lead to other products of unusual properties.

SPECIAL MAGNETIC ALLOYS

"Special Magnetic Alloys and Their Application," was the subject of G. W. Elmen and E. A. Gaugler (A '44) Naval Ordnance Laboratory, Washington, D. C. Although magnetic materials possessing substantially rectangular hysteresis loops have been known for some time, only re-

cently has this property been utilized in the design of electric apparatus. One of the earliest applications is for saturable resectors used in contact rectifiers. These rectifiers were developed in Germany during the war, and have been in commercial use since 1943. Another application of this type of material is for magnetic amplifiers. Development work on these amplifiers has been under way for some time at the Naval Ordnance Laboratory. The results so far obtained show that superior power output can be obtained when magnetic cores with rectangular hysteresis characteristics are used. While these are the outstanding applications up to this time, it is believed that when the full significance of rectangular hysteresis loops is appreciated by designers of electric apparatus, many more useful applications will be found, particularly in the design of saturable devices and equipment operated at high flux densities.

Mechanical Rectifiers. Attempts in the past to construct mechanical rectifiers have been frustrated because of the difficulties encountered in commutation. To obtain satisfactory results, the commutation must take place while the current passes through the zero value. In an ordinary a-c wave the rate of change is the greatest as it passes through zero. As a result there is no time for commutation without destructive sparking. When a saturable reactor is connected in the circuit a step is introduced in the current wave near the zero axis but this is not of sufficient duration nor is it parallel to the zero axis for sparkless commutation. When the magnetic material in the reactor has a rectangular hysteresis loop, the duration of the "step" is increased and it can be made to coincide with the zero axis, thus resulting in an almost sparkless commutation.

Magnetic Amplifiers. Development work in the Naval Ordnance Laboratory indicates that when the magnetic amplifier coils have cores with rectangular hysteresis loops, the power output in some instances can be double for the same size cores. Two methods of producing rectangular hysteresis loops are known. One of these is drastic cold rolling followed by a special heat treatment. This method was developed in Germany for the production of cores for the mechanical rectifier. The second method is magnetic annealing. This method increases the permeability of silicon steel and of some of the permalloys and perminvars. Bozarth and his associates of the Bell Telephone Laboratories have shown that this method in some instances also produces rectangular hysteresis loops. As the change in induction with rectangular hysteresis loop is very rapid, it is necessary to use very thin material. Cores for the mechanical rectifier are made from tape 0.0012 inch or 0.002 inch thick. These cores must be protected from mechanical strain and so they are protected by annular boxes on which the windings are placed.

PROPERTIES OF DIELECTRICS

"Properties of Dielectrics Composed of Titanates of the Alkaline Earth Oxides," was the subject of a paper by G. R. Shelton, National Bureau of Standards, Washington, D. C. Research on ceramic dielectrics has been stimulated by development of tiny capacitors used in electronic equipment where space is at a premium. Some ceramic bodies, particularly the titanates, are conspicuous because they exhibit high values of the dielectric constant. Such bodies are being produced commercially as dielectrics for instruments used in radio, radar, television, and hearing aids. At the National Bureau of Standards, current investigations on ceramic dielectrics include the determination of properties of titanates of the alkaline earth oxides. In the preparation of these dielectrics, mixtures in the proper proportions of titanium dioxide and carbonates of the alkaline earth elements were calcined and pulverized. The resulting materials were dry-pressed, at 20,000 pounds per square inch, in the form of disks 1/8 inch in thickness and 1/4 to $1^1/_2$ inches in diameter. The disks were heated to maturity as indicated by 0.1 per cent of absorption. Results were obtained for heat treatments, absorption, shrinkage, thermal expansion, dielectric constant (K) at -60 degrees to 85 degrees centigrade, also Q-values at 25 degrees centigrade for frequencies of 50 to 20,000 kc per second. Some measurements of K and Q were made at 3,000 megacycles per second.

The compositions of these dielectrics may be indicated in seven systems of oxides. The four binary systems are $MgO–TiO_2$, $CaO–TiO_2$, $SrO–TiO_2$, and $BaO–TiO_2$, while the three ternary systems are $BaO–MgO–TiO_2$, $BaO–CaO–TiO_2$, and $BaO–SrO–TiO_2$.

For dielectrics with compositions in the seven systems of oxides, the ranges in values of K and Q, measured at 25 degrees centigrade and 1 megacycle per second, are tabulated in the following:

System	Ranges in Values K	Q
$MgO–TiO_2$	12–97	69–10,000
$CaO–TiO_2$	60–144	350–10,000
$SrO–TiO_2$	97–260	2,600– 8,000
$BaO–TiO_2$	34–1,500	50– 5,000
$BaO–MgO–TiO_2$	12–1,550	9–10,000
$BaO–CaO–TiO_2$	35–2,700	30–10,000
$BaO–SrO–TiO_2$	34–18,000	50–10,000

In this series of investigations, the first paper "Properties of Barium-Strontium Titanate Dielectrics," has been published (*Journal*, National Bureau of Standards, 1947, page 337; *Journal*, American Ceramic Society, 1947, page 114).

POLYMERS FOR INSULATION

"New Polymers for Electrical Insulation," in particular du Pont materials "Teflon," polythene, nylon, and BCM, were discussed by J. R. Perkins (A '36) of E. I. du Pont de Nemours and Company, Arlington, N. J. "Teflon" is a polymer known as polytetrafluoroethylene and is composed entirely of fluorine and carbon. It is characterized by its ability to operate continuously at temperatures of 200–250 degrees centigrade without deterioration, its freedom from attack by chemicals and solvents, its outstanding low electrical losses at all frequencies up to and including the microwaves, its negligible water absorption, and its ability to withstand the action of an arc continuously without the formation of a carbonized path. Fabrication of the material is limited to the compression molding and extrusion of simple shapes. Tape is made by shaving from a molded cylinder. Major uses will be as a replacement for mica-filled tape in electric machinery and as wire and cable primary insulation.

Polythene came to the fore during the war as a primary insulation for radio and radar cables. It is composed of polymerized ethylene gas and contains only hydrogen and carbon. It is quite similar to Teflon in its physical and electrical properties at room temperature and slightly over. It is limited to applications with top operating temperatures not over 85–100 degrees centigrade dependent on the load. It is one of the easiest thermoplastic compounds to be injection- or compression-molded or extruded. It is, in addition, the lightest commercial plastic and is relatively cheap. The main uses are for wire and cable insulation, spaghetti tubing, electric tape, and potting compounds. With additional development, it is believed that it will have wide use as a dielectric in capacitors.

Nylon, or a polyamide, has had wide use in the textile industry. It now is being made in molding powder form and can be used for injection molding or in the extrusion of sheets, rods, and tubes. Nylon is characterized by very high melting points, high toughness and abrasion resistance, and excellent chemical resistance. Nylons find use in mechanical parts such as gears, racks, knobs, bushings, and bearings for light load in electric equipment, and as electric tapes, spaghetti tubing, magnet wire covering, and cable sheathing.

BCM was developed as a low-pressure laminating resin and particularly is suited for 2-stage laminating work. BCM is a polyfunctional addition-type monomer forming a thermosetting hard resin. The monomer is nonvolatile, very fluid, and polymerizes at low temperatures and pressures with the usual peroxide catalysts. BCM gives promise as a thermosetting molding composition using well in excess of 50 per cent of filler with short molding cycles. Injection molding with a cold cylinder and a hot mold and on a 15-second cycle cure seems practical. Compression is likewise more rapid. This compound using an asbestos filler should simulate the desirable properties of cold molded compounds but have the additional advantage of having much better dimensional tolerances than is usual with cold molded compounds.

POLYESTER RESINS

In a paper, "Polyester Resins as Elec-

trical Insulation," C. F. Hill (F '39) and N. C. Foster, Westinghouse Research Laboratories, East Pittsburgh, Pa., brought out the fact that within recent years a number of solvent reactive-type insulating varnishes have been developed which differ from conventional varnishes in that the solvent reacts with the base resin to become a part of the final solid. As the solvent does not evaporate, and there are no reaction by-products, essentially complete filling of electric apparatus can be obtained. It should be possible, therefore, depending upon the type of apparatus, to obtain improved heat transfer, heat resistance, dielectric strength, and heat stability. Most of these solvent reactive varnishes are made from polyester resins. In general, fumaric or maleic acid or anhydride are esterified with polyhydroxy compounds such as glycols, glycerol, and castor oil, to form resinous products. These are dissolved in monomers containing reactive ethylenic groups such as styrene or diallyl phthalate which, upon heating, will copolymerize with the resin to form thermoset products. These resins vary from high viscosity materials for surface coating or casting applications to low viscosity impregnating compounds. In hardness, they range from near glasslike to soft, elastomeric compounds. Electrically, the best of these are about equal to the usual high grade synthetic solvent-type resins now in use.

Wartime use has demonstrated the merit of materials of this type. Such varnishes, however, have comparatively short tank life and, in their use on some apparatus, it is necessary to employ special technics. A method of preventing run-out during baking has been developed and new application procedures and varnishes now are being studied so as to be able better to utilize these materials on standard postwar apparatus.

SILICONE MATERIALS

"Silicone Rubber for Electrical Uses," by R. O. Sauer, General Electric Research Laboratory, Schenectady, N. Y. The commercially new organosilicon products, the silicones, are providing the design engineer with a new class of materials of unusual characteristics. Unique features of the silicone elastomers are physical stability and notable elastic properties at high and at low temperatures, plus excellent resistance to heat breakdown, high temperature oxidation, ozone, and corona. However, the rubber is attacked chemically by concentrated acids and bases and swollen considerably by nonpolar aromatic solvents such as benzene and toluene. Although low in tensile strength, tear resistance, and abrasion resistance at room temperature, no other resilient and elastic material possesses the stability over the wide range from -55 degrees Fahrenheit to 520 degrees Fahrenheit of silicone rubber. The good electrical properties at elevated temperatures are attributable to the novel chemical structure and the absence of the usual plasticizing agents.

Silicone rubber differs fundamentally from the natural or synthetic elastomers in that the backbone of the more or less linear molecules is composed of atoms of silicon and oxygen alternately arranged, as contrasted to the predominantly carbonaceous skeleton of conventional rubbers. The differences in the properties of the various stocks now available lie to a large extent in the nature of the filler, the filler-to-gum ratio, and the degrees of vulcanization. The mechanical properties which, as mentioned, are somewhat inferior, may be improved by reinforcing agents such as glass or asbestos fibers.

Present-day electrical uses include insulating bushings for capacitors, lead wire insulation, special gaskets for high temperature lighting equipment, and for baking and drying ovens. Some gasketing applications depend upon the absence of a tendency to stick to metal or ceramic surfaces. Good adhesion to glass, steel, or ceramics can be attained by use of primers for the metal or ceramic and the additional use of a silicone adhesive. Several compounds have been developed for molding (either compression or transfer), for extrusion, and for coating glass cloth and tape. In brief, silicone rubber is a chemically novel, heat-stable elastomer which has good electrical and chemical properties and which can be handled much as familiar elastic materials.

"Silicone Materials for Electrical Uses," by T. A. Kauppi (A '44) Dow Corning Corporation, Midland, Mich. In the silicones, much of the stability of such inorganic insulating materials as glass, mica, and quartz, which all are based on the same silicon to oxygen linkages, is combined with the ease of handling generally associated with organic plastics. Being semi-inorganic in chemical structure, the silicones retain their mechanical properties and their chemical composition over a very wide temperature range. Consequently, their electrical insulating properties are changed little by various types of aging. Silicone products in the form of liquids, compounds, insulating varnishes, thermosetting resins, and rubberlike bodies, all have useful electrical insulating properties.

Silicone fluids are available in viscosities ranging from 0.65 to 1,000,000 centistokes at 25 degrees centigrade. Those useful as liquid dielectrics have dielectric constants ranging from 2.18 to 2.76 at 1,000 cycles and power factors in the order of 0.01 per cent at 1,000 cycles. These values are relatively constant at frequencies up to 10^8 cycles per second and over a wide temperature range. These same fluids are used as water-repellent treatments for glass and ceramic insulators to maintain high surface resistivity even under moisture condensing conditions.

Silicone insulating compounds are water-repellent and nonmelting. They have a dielectric constant in the order of 2.8 at 1,000 cycles; power factor of 0.06 to 0.07 per cent at 1,000 cycles; and volume resistivity at 25 degrees centigrade in excess of 1×10^{14} ohm-centimeters.

Silicone insulating varnishes used to bond and impregnate inorganic insulating materials have made possible a new class (class *H*) of electrical insulation. Carefully controlled accelerated life-testing of silicone-insulated and class *B* motors indicates that silicone varnishes give ten times the life and ten times the wet insulation resistance afforded by the best insulating varnishes previously known. Longer life and more reliable service; the ability to withstand sustained overloads, high ambient temperatures, or excessively damp or corrosive atmospheres; or more power per unit size and weight may be expected to result from use of silicone insulation. Silicone greases and silicone enamels have been developed to withstand the higher permis-

J. E. Hobson (M '41) Illinois Institute of Technology (right) with Director A. C. Monteith (F '45) chairman of the Pittsburgh Section and member of the general committee for the winter meeting (center) and Director J. R. North (F '41) Commonwealth and Southern Corporation (left)

sible operating temperatures of silicone-insulated machines.

A thermosetting silicone resin is available as a bonding agent for inorganic fabrics in the production of rigid electrical laminations. Typical silicone-glass laminates have loss factors of 1.95 at 1 megacycle and 3.15 at 100 megacycles; wet insulation resistance in the order of 120,000 megohms; American Society for Testing Material arc resistance of 300 seconds; water absorption after 25 hours of 0.21 per cent; and heat distortion greater than 250 degrees centigrade. Silicone molding materials are in the experimental stage. They may be expected to have insulating properties comparable to those of silicone-glass laminates.

PERMAFIL

"Permafil for Electrical Applications," J. A. Loritsch, General Electric Company, Schenectady, N. Y., discussed General Electric "Permafil" which evolved from a project begun ten years ago in the research laboratory. This project was intended to develop a material of 100 per cent reactivity and suitable for impregnating and insulating coil structures. Permafil has these distinctive characteristics:

1. One hundred per cent reactive ingredients—no inert solvent.

2. Through-curing without formation of volatile by-products.

3. Through-curing without need of oxygen.

With these properties it becomes feasible to produce coil structures which are corona-free, show relatively constant power factor over a wide range of voltages and temperatures, give unusually good performance in high humidities, and dissipate, with direct voltages, more than the normal wattage.

Such coil structure performance permits: reducing size and weight of transformers and magnet coils while retaining the same rating as for a conventional design; or, increasing the rating of a unit while retaining the same size and weight as for the conventional design.

It is also significant that equivalent quality can be produced in coil structures such as field coils and armatures with reductions in labor operations. In other instances improvements can be effected in coil structures applying Permafils by conventional methods. This type of material eventually will assume an important part in the manufacture of electric apparatus.

WELDING OF GLASS

"The Welding of Glass With a High-Frequency Electric Torch," was the subject of E. M. Guyer (A '45) Corning Glass Works, Corning, N. Y. The electrical nature of glass is such that three different kinds of electric heating are applicable to glass working operations in three different temperature ranges. At low temperatures where glass is an insulator, high-frequency dielectric loss heating is effective. At elevated temperatures where glass behaves as an electrolyte with mobile ions, electric conduction heating is more efficient and less expensive. At very high temperatures, conducting glasses with low viscosity can be worked by high-frequency induction heating as applied to carbon and metal products. A powerful and versatile new tool for the glass worker—"the electric-cross-fire"—has been developed at the Corning Glass Works which utilizes electrically conducting needle flames. While too small for glass melting, these pin-point fires preheat localized areas to temperatures where the glass becomes an electric conductor. High-frequency current then is passed through the flames into the glass and the operation is completed by electric melting. This high-frequency electric torch performs old operations faster or more easily than conventional glass fires and makes possible new operations formerly too difficult to be practical. As a result, new glass products are manufactured to closer tolerances in the welding shop and high melting temperature industrial glass structures are built with mobile welding units in the field.

Glassware in current production by these novel methods ranges from miniature optical cells and accurately calibrated laboratory ware to 20-inch television tubes, glass doughnuts for multimillion-volt electron accelerators, and many miles of field-fabricated Pyrex pipe line. Operations in both shop and field demonstrate certain definite advantages of electric glass welding in comparison with conventional flame sealing. These may be summarized briefly as follows:

1. Electric heating provides deep penetration into thick sections of high melting temperature glass.

2. High temperatures can be attained rapidly without destructive boiling of the surface.

3. Electric heat can be localized sharply leaving adjoining glass undistorted.

4. More accurate temperature control is attainable and uniformity of results is better in repeated operations.

5. Faster operation is possible as a result of more efficient heating combined with better localization which means that less glass has to be heated.

In his paper, "Sulphur Hexafluoride," J. T. Pinkston of the Harshaw Chemical Company described an unusual gas known as sulphur hexafluoride which is used as a compressed insulation for electric equipment. It is now available in large quantities which can be poured as liquids, which, before World War II, was a laboratory curiosity.

M. C. Caine of the Monsanto Chemical Company pointed out in his paper, "New Plastic Materials for Electrical Industry," that Styrene, a transparent plastic much used for moldings, was improved greatly as a result of wartime research. This was important for wartime radar and has been extended recently by still greater improvements.

J. H. Scaff, of the Bell Telephone Laboratories, in "Rectification Properties of Silicon and Germanium," discussed the wartime improvements which were made on the old "cat whiskers" detector for radar use. The modern detector uses a tiny metal spring in contact with metallic silicon or germanium, a rare metal, and is becoming a serious competitor of the vacuum tube in very-high-frequency radio and radar.

Also presented at this session was a paper on "CEROC Teflon" by Stanley Dorst (A '35) Sprague Specialities Company, North Adams, Mass.

Technical Session Covers Steel Mill Power Supply

Under the chairmanship of D. L. Beeman (M '43) General Electric Company, Schenectady, N. Y., a technical session on Monday, January 26, was devoted to power supply in steel mills. The program consisted of one technical paper and three conference papers.

ECONOMICS OF PROCESS STEAM

"Economics of Process Steam Generation," by William E. Zelley, John A. Roebling's Sons Company, Trenton, N. J., discussed the advisability, possibilities, and benefits that may be derived by the generation of all or part of the electric power required by a plant by means of extraction-type turbogenerators. The use of extraction turbines is not new in the field, but has been used in a great many applications in the past, and the over-all savings that can be made by generating the steam required for general plant use at relatively high pressures and temperatures and reducing those pressures and temperatures to the lower values required for general plant heating and process steam uses, makes possible the generation of considerable power at a very low cost. Some comparisons between the cost of generation in the usual conventional manner and that generated by extraction were made, and Mr. Zelley also discussed the cost of supplying power to a plant, both when all power is purchased and when a portion of the power is purchased from the utility company. The plant described has need for a considerable quantity of steam at relatively low pressure and, because of that, it is economically feasible to justify the installation of the extraction-type turbogenerator.

INDUSTRIAL PLANTS

"Electric Power for Industrial Plants," was discussed by F. D. Troxel (M '40) Sargent and Lundy, Chicago, Ill. In the early days of the use of electric power in industrial plants the planning and engineering in connection with the generation and distribution of this power was not done as carefully as in the case of utility generating plants and distribution systems. Down through the years there has been, however, a gradual improvement in the quality of the electrical facilities in industrial plants. When no process steam is required it is usually more economical and satisfactory to purchase electric power from the local power company. However, when low pressure steam is required for process work, or when fuel is produced as a by-product of process work, it is many times economically very attractive to install high pressure boilers and to generate electric power, using the turbine as a reducing valve for the supply of low

pressure process steam, as required. When this is done it is usually desirable to have an interconnection with the local power company as the principal problem in such industrial plants is to obtain a correct balance between the electric and steam loads. Mr. Troxel described the general features of the design of electric generation and distribution facilities for industrial plants and pointed out the desirability of making such facilities reliable, simple for operating, safe, and easy to maintain. Reliability is obtained by the use of metal-clad switching equipment with a minimum of cross ties and reserve feeds, safety is obtained by the metal-clad switching equipment and a suitable interlocking and a consistent design in which all live parts are closed off during normal operation. Ease of maintenance is provided in the form of removable-type circuit breakers, relays, and so forth, and in the use of simple standard equipment.

This problem now is being given much more thought than formerly, and, as a result, much better reliability and a much better design is being obtained for most industrial installations.

SUDDENLY APPLIED LOADS

"Suddenly Applied Loads Carried by a Variable-Ratio Synchronous-Induction Frequency Changer" (48-15), was the title of a paper by A. G. Darling (M '44) of the General Electric Company, Schenectady, N. Y., and G. A. Kaufmann, of the Jones and Laughlin Steel Corporation, Pittsburgh, Pa. Parallel operation of a 25-cycle power plant and a 60-cycle utility feeder has been accomplished by an induction-synchronous variable-ratio frequency changer with Scherbius-type excitation for the induction machine. Amplidyne control is such that it tends to hold a constant demand on the 60-cycle power supply and allows the 25-cycle turbine generator to supply the fluctuating load, including that of a hot strip mill. Should the powerhouse be shut down, the 60-cycle line and frequency changer could supply the essential load indefinitely.

LOAD SWING EFFECT

The final paper in this session was "Effect of Load Swings on Frequency and Tie-Line Load Control," by T. E. Purcell and A. P. Hayward (A '30), both of Duquesne Light Company, Pittsburgh, Pa. This paper outlines load control requirements of the Duquesne Light Company, serving a district in which the major industry is steel or related products. This heavy industrial load will not have the diversity inherent with smaller industrial loads, therefore changes in the electric furnaces and the continuous strip mill demand appear directly as system load variations and required direct action of the load control equipment. The regulated problem is rather complex and involves the following factors, each of which was discussed in detail in the paper. Control must be provided which is responsive to kilowatts to regulate the Valley-Ellwood City tie-line and the Colfax-Springdale tie-line; load control equipment must be provided within the regulated stations to distribute the load changes on a basic instrumental load sequence; similar load control equipment must be provided for the system to distribute the load changes between stations on a basic instrumental load schedule; steam must be provided within the system control to parallel regulating station during severe load changes; frequent devised control must be provided; diversity control must be provided for the Colfax-Springdale tie-line; scheduled integration control has been provided for the same tie-line; high speed regulation must be provided which is responsive to tie-line load capable of following strip mill cycles; speed droop compensation for turbine governors to assist frequency controls must be provided; and a load regulator must be provided not responsive to cyclic load swings, but one that provides fast response for large load changes and one that can limit maximum rate of response.

The technical details of the regulating equipment were not included except as required to clarify the discussion. The original control installation provided simple tie-line load with allocation of load within the Colfax power station on an incremental schedule. As the severity of the load variations increased, the simple control was modified to give stable operation with the cyclic load swings of steel mills and the erratic load of other heavy industries. The allocation of load between stations was arranged to provide parallel control which divides the regulating burden between two boiler plants.

Session on Transmission Line Protection Features Papers by Working Groups

Three interesting papers were presented at the session on relay protection of transmission lines on Monday, January 26, 1948, at the winter general meeting. These papers were the result of a study of a typical transmission system having short, medium, and long lines. The working groups of the transmission line protection group were responsible for the preparation of the papers. The three papers presented some of the factors and problems entering into relay application on transmission lines, and it was hoped that these papers, together with the discussion at the conference, will be combined into a useful report on transmission line protection at an early date. E. L. Harder (M '41) Westinghouse Electric Corporation, East Pittsburgh, Pa., presided.

SHORT LINES

"Transmission Line Protection of Short Lines of a Typical System" was a paper prepared by the short line working group consisting of W. E. Marter (A '40, *chairman*), E. L. Michelson (M '44), W. A. Lewis, Jr. (F '45) and K. N. Reardon (M '45). It was pointed out by this paper that the use of pilot wire protection can be justified economically. The following items should be considered, and, where necessary, included in pilot wire protection:

1. Rise in station ground potential and induction should be studied to determine whether neutralizing transformers are required.

2. Consideration should be given to the installation of continuous supervision on the pilot wire circuit for the purpose of cutting out pilot wire protection when the pilot wire circuit becomes defective, and also for the purpose of automatically switching the backup protection where simple backup is used, and where there may be some question of the backup operating unnecessarily under certain system conditions.

3. Use of instantaneous phase and ground overcurrent relays with their trip contacts in series with the pilot wire relay trip contact should be considered. These relays have been found to be very successful in preventing unnecessary operation of the pilot wire relay due to foreign voltage on the pilot wire circuit from such causes as accidental application of telephone test voltages, contact with other pairs in the same telephone cable, contacts with power circuits, and induction from circuits at voltages below the voltage of the protected line section.

The philosophy of backup protection also was discussed in this paper. The type of protection described provides independent relays fed from independent current transformers and provides backup for a mechanically sticking circuit breaker. It is assumed that, with this type of backup, failure of two pieces of equipment will not occur at the same time. This type of backup protection has distinct operating advantages, in that it is possible to remove a complete set of protection equipment from service for testing and maintenance purposes without requiring an outage on the protected line section.

MEDIUM LINES

"Relay Protection for Medium-Length High-Voltage Transmission Lines," was a paper prepared by J. H. Kinghorn (M '46) and B. C. Hicks (M '45) of the medium length lines working group. A typical medium-length high-voltage line transmission system was used as an example, and some of the advantages and disadvantages of various protective systems were considered. The discussion was confined to types of relays available as standard equipment, although it was pointed out that there was the possibility of special schemes for special purposes. Various protection schemes were discussed, including one 2-cycle relay, carrier current relay, phase comparison carrier, directional comparison carrier, phase backup relay, 3-step impedance relay, simple overcurrent relay, and ground backup relay. The relative cost of the various schemes also was considered. The figures presented indicated that if a standard carrier relay setup is purchased, a small additional premium must be paid to obtain a phase backup setup using relays separate from those employed for the carrier. However, it is possible to employ special relays for a carrier which has only the features which are needed for the carrier

functions that are reduced considerably. This can be combined with time and continued separate backup relays for a total cost of about 90 per cent of the standard carrier cost. If it is combined with separate 3-step impedance backup, the total cost is about 3 per cent higher than that of a standard setup. It was pointed out that the cost of relaying and carrier-type protection was small compared with the equipment and service which it protects, thus the choice of backup protection and the carrier-type protection is dependent primarily on the technical advantages which it offers on important lines. The relay protection arrangement suggested included the following: For primary protection, directional comparison carrier current relaying using impedance-type phase relays and ground preference scheme; for backup protection at two of the stations, (phase protection) 3-step impedance relays, and (ground protection) simple instantaneous plunger relays and inverse time induction relays; and at the other two stations for phase protection, simple instantaneous plunger-type relays, inverse time induction overcurrent relays with voltage control, using the carrier directional relay; and for ground protection, simple instantaneous plunger-type relays using the carrier directional relay and product-type time delay relays.

LONG LINES

C. E. Parks (M '45) and W. R. Brownlee (M '38) of the relay committee were the authors of the final paper "Consideration of Requirements and Limitations of Relaying and High Speed Reclosing on Long and Heavily Loaded Transmission Lines." Here again a typical system was considered, and, to provoke discussion and bring out additional information for further study, a number of tentative conclusions were offered. It was pointed out that high speed reclosing of important tie-lines should receive favorable consideration. Either 3-pole or single-pole reclosing might be applied, depending on the system stability characteristics and on the number of single-phase-to-ground and multiphase faults. Either type of reclosing imposes severe requirements on transmission line relaying. Distance relay elements with modified impedance characteristics provide reduced susceptibility to swing current, but usually are not sufficient for the more severe application. Time impedance sequence blocking is seldom applicable to the longer tie-lines, as system reliability requires that an actual out-of-step condition be cleared on the first swing. Carrier relaying based on modified impedance relay elements can minimize the possibility of undesired tripping, provided the first and second zone distance relay backup elements are normally out of service. Finally, relaying schemes which minimize the possibility of incorrect tripping involve severe compromise with backup protection, especially protection against the rare failure of a circuit breaker to trip. Further investigation of methods of backup protection is indicated.

Varied Topics Presented at Session on Electronic Instruments

One Monday session of the AIEE 1948 winter general meeting in Pittsburgh, Pa., was devoted to the presentation of six conference and technical papers on electronic instruments. Cochairmen at the session were W. R. Clark (M '44) of Leeds and Northrup Company, Philadelphia, Pa., and J. G. Reid, Jr.

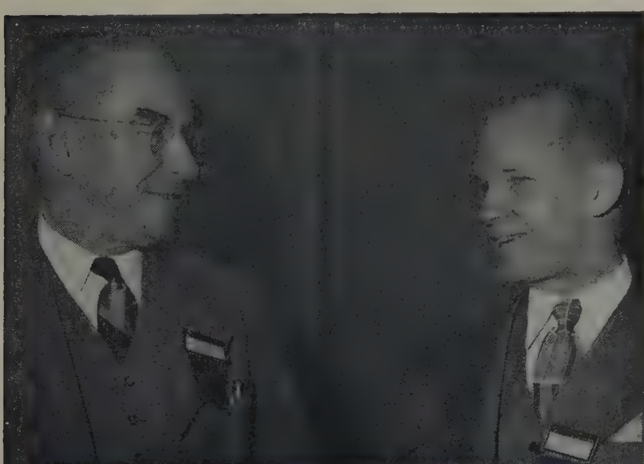
SUPERSONIC REFLECTOSCOPE

"Electronic Circuits of a Supersonic Reflectoscope" (48-21), was presented by Ralph B. Delano, Jr. (A '46) of the Sperry Products, Inc., Hoboken, N. J. The "Reflectoscope," working on the echo-analysis principle of radar, can detect a flaw of one-eighth inch perpendicular projection on the axis of the supersonic beam at a distance of ten feet from the surface. The entire electronic instrument, which may be subdivided into sweep, delay, pulse generator, crystal or searching units, main amplifier, and marker circuit, operates from unrectified 60-cycle line voltage. This is possible because of the short duty cycle in relation to the idle period and the synchronization of the duty cycle with the alternating voltage. Details of construction, operation, and use of each component of the instrument were discussed in detail.

D-C AMPLIFIER

A "D-C Amplifier Stabilized for Zero and Gain" (48-9), has been developed for making measurements of small direct voltages or currents and was described in a paper by A. J. Williams (M '45), R. E. Tarpley (A '29), and W. R. Clark (M '44), all of Leeds and Northrup Company, Philadelphia, Pa. The d-c signal to be measured is converted to a 60-cycle signal by a contact-type vibrating modulator, amplified, reconverted to direct current, and measured in a feedback-type circuit. Circuit variations and refinement for general and specific applications were given, as well as the circuit constants in each instance. Zero stability is attained to a large extent by the d-c to a-c conversion but careful electric and magnetic shielding, filtering, insulating, shock mounting of circuit tubes, decrease of loop sizes, and minimizing thermoelectric effects by matching metals and temperatures aid in minimizing zero disturbances. Stable gain is secured by providing adequate forward gain and taking measures to

AIEE Vice-President C. F. Terrell (F '46) Puget Sound Power and Light Company (left) deep in conversation with Tomlinson Fort (M '35) chairman of the membership committee



Lloyd F. Hunt (F '38) Southern California Edison Company, Ltd., (left) discusses the week's events with C. F. Wagner (F '40) of the publications committee

prevent oscillation, overload, unwanted feedback, and unwanted phase shift. Calibration of resistors and characteristics of the recording instruments also limit the over-all performance of the amplifier. Response curves were shown and methods of securing the desired response discussed.

OSCILLOGRAPHS

A conference paper by W. G. Fockler (A '45) Allen B. DuMont Laboratories, Inc., Passaic, N. J., described "High-Voltage Cathode-Ray Oscillographs for High-Speed Transients." The sealed-off hot cathode-ray tube operated at high post-accelerating potentials is being used for visual observation and photographic recording of high-speed single transients. These tubes operate at total accelerating potentials of from 10 to 29 kv. They are used to photograph transients which may last as long as 50 microseconds and in which possible variations occur within time intervals of 1/100 of a microsecond or less. During these transients the beam may be traveling at speeds up to the order of 200 to 400 inches per microsecond.

Former commercial tubes of the sealed-off type have been capable of recording speeds in the order of 5 to 8 inches per microsecond at rated accelerating potential. The inadequacy of these tubes in the high-speed transient field led to the development of the type 5RP-cathode-ray tube with which it has been possible at 12-kv accelerating potential to record 100 inches per microsecond. Increasing the accelerating potential to 29 kv increased the recorded speeds to 400 inches per microsecond.

Requirements of an instrument capable of economically furnishing power, yet portable, and flexible with respect to applications requires special design techniques. The positioning supply must be regulated to maintain constant d-c potentials at deflection plates. The intensifier or post-accelerating supply and the negative or second-anode supply must be regulated to hold the acceleration potential constant independent of the beam current required to display the transient.

Recordings of the standard voltage impulse test waves as taken from the instrument were shown, as well as a visual demonstration of the same plus other high-speed phenomena. Two cameras have been developed specifically for oscillographic work. The first is a single-exposure type using 35-millimeter film and an f/3.5 coated lens. The second camera is of the continuous-motion type using an f/2.8 lens and 35-millimeter film. The speed of film travel may be varied from 1 foot per minute to 60 inches per second.

"FAIL-SAFE" OPERATION

An important consideration in the design of many electronic circuits for the control of industrial equipment is that the circuits must "fail-safe." Likewise, indicating circuits, in many cases, must fail showing their inoperative condition. A paper called "'Fail-Safe' Operation of Electronic Circuits," by G. D. Hanchett, RCA Manufacturing Company, reviewed the possible causes of failure with conventional circuits and suggested means of modifying these circuits so that they will be "fail-safe." The failures discussed in detail were those resulting from tube aging, those from tube short or open circuits, and those resulting from other component parts defects. The methods for making such failures occur in the proper direction for "fail-safe" operation were examined and illustrated by a basic circuit utilizing the type 2D21 tube and incorporating "fail-safe" operation. This tube is a thyratron with a shield grid that has connections made to both ends of the shield grid and these are brought out so that external connections may be made accordingly. The special connections are provided so that the cathode return circuit may be made through the shield grids. The main idea of "fail-safe" operation is to arrange the circuit so that all tube elements carry current in such a manner that any failure of the circuit causes an interruption of current which, in turn, causes the protective relay to drop out. In the event of a short circuit, the "fail-safe" type of circuit is so arranged that the short circuit will cause a reduction of the current flowing into the various tube elements, and thus "failing-safe." The author pointed out that the tube crystals for "fail-safe" operation require the use of positive grid operation and returning the cathode current through the shield grid connections. These principles properly applied will result in a very satisfactory "fail-safe" electronic circuit.

ELECTRONIC FAULT LOCATOR

An interesting instrument was described in a paper called "'The Linascope'—An Echo-Ranging-Type Fault Locator for High-Voltage Lines," by J. R. Leslie (A '39) and K. H. Kidd (A '47), both of The Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada. An electronic fault locator was described which uses an echo ranging method for determining the location and nature of transmission line faults. This device has been used on open wire telephone circuits for the location of various fault conditions, including open circuit, short circuit, and high resistance joints. Tests have been performed on high-voltage transmission lines which were removed from service for the purpose. Artificial faults applied at distances as great as 300 miles were detected. Open- and short-circuit failures are observed readily by means of this locator. Transposition points give slight echoes, it was pointed out. The equipment has been used for inspecting live lines. In this application a high-frequency pulse is used which is coupled to the line by means of a high-voltage coupling capacitor. Mention was made that it is intended to use photographic recording gear with this instrument for the continuous inspection of live lines, in order to locate transient faults such as occur with lightning flashover of live-line insulators.

OIL FILM THICKNESS

The "Oil Film Thickness Indicator for Journal Bearings" (48-96), described by M. L. Greenough of the National Bureau of Standards, Washington, D. C., is essentially an eccentricity indicator for shafts in sleeve-type bearings. Subtracting the eccentricity from the value of radial clearance yields the oil film thickness. Without physical contact with the shaft or effecting the bearing performance, the output from four probes mounted at 90-degree intervals are connected to a calibrated cathode-ray oscilloscope to indicate instantaneous eccentricity and vibration. Based upon the principle that when radio-frequency current is impressed upon a primary winding, the voltage induced in a secondary coil is proportional to the primary current, its frequency, and the mutual inductance, each probe depends upon variation of mutual inductance to measure the distance between the secondary coil and an electroplated copper band on the shaft. Effective band widths of the probe output is in the order of 2,000 cycles per second, and over-all accuracy appears to be better than 0.0005 inch.

Transformers are Topic of Technical Session

Transformers were the topic of one technical session on Monday, January 26, of the AIEE winter general meeting. The chairman at this session was H. B. Keath (F '30) Wagner Electric Company, St. Louis, Mo.

INFLUENCE OF CORE FORM

Rigorous mathematical analysis of the "Influence of the Core Form Upon the Iron Losses of Transformers" (48-18), was given by G. M. Stein (M '38) of the Westinghouse Electric Corporation, Sharon, Pa. By developing a "fictitious core weight" which, multiplied by the specific loss in the leg center, represents the total iron loss, greater accuracy in the calculation of core losses is possible. The desired formulas derived are based upon analysis of the actual field in the transformer core.

TERRATEX

T. R. Walters (M '39) of the General Electric Company, Pittsfield, Mass., reported that "Terratex—A Thin, Flexible, Inorganic Insulation" (48-20), is the class *B* counterpart of class *A* cellulose paper insulation. Made of purified asbestos fibers with mineral binder and filler, fairly standard paper-making machinery can be used to produce sheets of 1- to 10-mil thicknesses. Physical properties, such as tear and tensile strength, of the paper are sufficiently high for effective use and extremely stable with time and high temperature. Correct varnish treatment increases the tensile strength. Many uses will develop for this new class *B* insulation, but at present the major ones are as layer insulation, mica backing, and a mica substitute.

INSULATION DETERIORATION

An alternative to the 7- or 10-degree law now used for accelerated life tests

was given by Thomas W. Dakin of the Westinghouse Electric Corporation, East Pittsburgh, Pa., in his presentation of "Electrical Insulation Deterioration Treated as a Chemical Rate Phenomenon" (48-19). Accurate means of extrapolating the results of controlled temperature accelerated aging tests of insulations were developed based upon the analysis long used by physical chemists for investigating rates of reactions. Insulation deterioration can be analyzed as specific chemical changes, dependent upon the amount of certain chemicals present, which will reach a certain end point in a finite period.

"Steel" Provides the Keynote for Discussion at Technical Session

With steel as the subject of two conference and one technical paper, a session was held on Tuesday, January 27, in Pittsburgh, under the joint chairmanship of F. W. Cramer (M '40) Carnegie-Illinois Steel Corporation, Pittsburgh, Pa., and T. B. Montgomery (M '41) Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

ELECTRIC EQUIPMENT

An electric control system for a modern high-speed tandem mill is as interesting and as intricate as those encountered in any field of engineering, said W. E. Miller (M '45) of the General Electric Company, Schenectady, N. Y., in his presentation of "Electric Equipment for Cold Strip Reduction Mills" (48-22). After a brief explanation of type of mills and methods of selection of electric equipment, he stated that as the operating speed of mills are increased, the importance of keeping the mill "on gauge" during the initial acceleration and the final deceleration periods becomes more important. Although "tapered tension control by motor field adjustment" can be used to adjust automatically the strip tension between stands, "*IR* drop compensation" (independent control of motor armature voltage by an amount equal to or a part of the *IR* drop in the system) seems to be the preferred method. A controlled reference voltage is supplied to each motor generator set by a control bus. Thus the voltages of all the generators and the excitation of the generator field exciters is proportional for all generators. Individual voltage adjustment may be accomplished by movement of the stand master rheostat. Each stand motor speed also can be controlled by adjustment of its shunt field current. An ohmic drop exciter receives its excitation from the voltage drop across the generator commutating field, and its proportional output voltage is subtracted automatically from the generator terminal voltage. Each stand regulator, through its regulating exciter, acts to hold essentially constant motor voltage which is directly proportional to motor speed. Constant tension regulation for the reel windup following the last stand usually is provided by current regulation. However, tensiometer-type tension regulation may be used to hold constant tension by changing both motor armature voltage and motor field excitation. This type of regulator prevents the design of the reel motor from becoming the limiting factor in modern high-speed mills. Installations in operation, Miller concluded, have proved that predictions made from design calculations were well founded.

FLYWHEEL EFFECT

"WK^2 Aspect of High-Speed Mills," by J. F. Sellers (M '43) and T. B. Montgomery, both of Allis-Chalmers Manufacturing Company, Milwaukee, Wis., was presented by T. B. Montgomery. In recent years the demand for higher and higher production rates calling for progressively higher speeds of mills and drive motors has prompted designers to use the so-called "stovepipe" motor, which is a unit having minimum diameter and resulting long core length for a given rating, in order to reduce the radius of gyration to a minimum. Years of experience in operating practice have dictated certain design limitations, and consideration of WK^2 (flywheel effect of mill and motor) values in this study were made in conformity with a design which has been proved in practice. The paper considered such factors as transients, tension controls, reduced horsepower operation, and economic considerations. The author concluded that in building a mill, the steel mill engineer must find the most practical solution to the problem of availing himself of adequate horsepower for present production in low carbon steel and of providing a margin that will serve for stainless and other alloys which future production requirements may necessitate some day. If margin in maximum horsepower is provided, consideration must be given to provide reasonable transient factor and breaking factor for the lightest strips to be rolled so that the mill may be controlled readily when rolling these strips. In several examples it was shown that while the motor WK^2 is reduced the reduction is not worth the extra cost of complication. With higher strip speed and shorter accelerating time, this factor becomes of more importance.

TIME DELAYS

"Some Generalizations Regarding Time Delays and Their Importance in Regulator Systems," were made by W. O. Osbon (M '41) Westinghouse Electric Corporation, East Pittsburgh, Pa. The current widespread activity in the application of various types of regulating systems in the metal working industry has created among those who apply and use such systems a need for a better appreciation of some of the factors involved in their design. There are in general three measures of the quality of performance of a regulated system: the steady-state accuracy, the speed of response, and the system damping or the rate of decay of oscillations. The steady-state accuracy depends upon the over-all amplification of the system. If a system is well damped, its speed of response is a measure of its ability to follow rapidly changing conditions. This characteristic depends upon the system amplification, but it also is influenced greatly by the time delays introduced by the electric machines.

The speed of response of an individual machine, as measured by its field circuit time constant, is related rigidly to the amount of energy stored in its magnetic field and to the rate of dissipation of energy in the excitation circuit. Thus, when a specified flux density is required in a given air gap, there is no royal road to rapid response of the machine except by the dissipation of energy in the field circuit. This condition applies to the multistage armature-excited machines used extensively in regulated systems, as well as to machines of conventional design. The most common method of reducing the time constant of a field circuit is by adding series resistance. An equivalent method which has important advantages in many instances is to connect the armature of the machine in series opposition with the excitation source.

Most regulated systems contain two or more time delays and it can be shown, in general, that optimum performance is possible when the ratio of the largest time constant to the smaller ones is maximum. Thus it is usually possible to improve regulator performance either by reducing the small system delays or by increasing the large one. When the large one is increased, a higher steady-state accuracy can be achieved, without impairment of the system damping or rate of response, if the system amplification also is increased. On the other hand, if the smaller time constants are reduced, both the accuracy and speed of response can be improved without impairing damping if the amplification is increased simultaneously.

Various "synthetic" means of modifying the effective time constants of a system (as contrasted with the actual time constants of the machines) are available. These include the special antihunting or stabilizing circuits and devices which are used extensively in regulator practice.

Five Papers Discuss Rotating Machinery

A session on Tuesday morning, January 27, was devoted to the presentation of five technical papers on rotating machinery. Chairman at the session was C. E. Kilbourne (F '46) General Electric Company, Schenectady, N. Y.

EQUIVALENT CIRCUITS

Gabriel Kron (M '45) of the General Electric Company, Schenectady, N. Y.,

presented his paper, "Steady-State Equivalent Circuits of Synchronous and Induction Machines" (48-27), by reviewing briefly the equivalent circuits which had been developed for the various types of salient pole synchronous and induction machines. These circuits are based upon already presented "primitive" machines calculations and in a like manner are given tensorial treatment and are expressed along the physical direct and quadrature axis.

INDUCTION GENERATOR

Detailed mathematical analysis of "An Induction Generator Used With the All-Electric Automatic Pilot for Airplanes" (48-28), was presented by Herbert Vickers (F '34) of the Smith Electric Company and Clarke, Chapman and Company, Cricklewood, London, England. This special type of induction generator was designed to satisfy two demands: that the voltage in the single phase must be linearly proportional to the speed at which it is driven, and that the phase angle between the signal voltage and the reference voltage must not change more than a small fraction of a degree over the speed range. Two phases in quadrature are accommodated by the slotted-core stator—one, the reference phase, is supplied with 400-cycle current, and the signal voltage is derived from the other phase. A high-resistance squirrel-cage rotor with fixed iron core is used. Vector diagrams and rigorous mathematical solution for magnetomotive forces, fluxes, voltages, and currents were given. This method also can be applied to calculations for single-phase induction motors.

SINGLE-PHASE SYNCHRONOUS MACHINE

"The Single-Phase Synchronous Machine" (48-29), by Ira A. Perry (F '37) of the General Electric Company, Fort Wayne, Ind., and B. L. Robertson (M '43) of the University of California, Berkeley, Calif., describes the theory of performance of single-phase synchronous machines. After a short discussion of the type and usage of single-phase power and synchronous machines in railway electrification, small plants, induction furnaces, and testing laboratories, the paper launches into a detailed mathematical analysis of the single-phase synchronous machine. Based upon the flux-leakage equations previously developed for the 3-phase machine with direct and quadrature axes of symmetry and one phase winding left idle, the results of equations include the effects of harmonic voltages and currents. Vector diagrams of excitation and torque-angle characteristics were given to illustrate the equations, and the result of change of load and change of circuits were considered.

Test data to substantiate the calculations of the previous paper were given next in the paper, "Performance of the Single-Phase Synchronous Machines" (48-30), by B. L. Robertson (F '43) of the University of California, Berkeley, Calif., and T. A. Rogers (M '37) of the University of Southern California, Los Angeles, Calif. Complete load runs were made on the single-phase synchronous machines under both generator and motor action with different values of power factor. Calculations for interpretation of test data indicates that armature resistance, which usually is neglected in synchronous machine studies, may be quite important in this instance, and that third harmonic magnitudes do not appreciably affect machine performance.

COMMUTATION ARMATURE

"A Study of the 3-Phase Commutator Armature with Six Adjustable Brushes" (48-31), was presented by Paul W. Franklin (A '39), of the Continental Electric Company, Inc., Newark, N. J. Rigorous mathematic derivation of all resistance and leakage reactance values as a function of the brush facing proved that in a 3-phase armature with two brushes per phase and coils with 100-per-cent pitch, the current distribution in the conductors is independent of the resistance and leakage values of the individual branches, regardless of brush shift. Hence, simple effective resistance in leakage reactance formulas may be derived.

Material Handling Included on Winter Meeting Program

A session featuring three conference papers on material handling was held on Tuesday, January 27, 1948. The session was presided over by E. M. Hays (M '43) Dravo Corporation, Pittsburgh, Pa.

NEW MILL MOTOR

The "Features of New 600 Series Mill Motor for Material Handling Applications," were described by C. B. Hathaway (A '40) Westinghouse Electric Corporation, East Pittsburgh, Pa. The new 600 line of mill motors has been approved by the Association of Iron and Steel Engineers as a standard line of motors for the steel industry. They supersede the present line as an AISE standard. The number of ratings available has one additional size added to it; namely, the 200-horsepower size. The listing of the one-fourth hour, one-half hour, and five hour rms ratings have been cancelled. There are to be but two ratings for an enclosed motor. They are the one hour and the five hour continuous. There is also a lineup of protected self-ventilated ratings. They will be listed as one hour and continuous.

Each rating is placed on a frame size smaller than it was formerly except for the number 2 frame. The 5-horsepower rating will be carried over from the old line to the new and the number will not be changed. That is to say, the 5-horsepower rating is on the AISE frame number 2 both in the old lineup and in the new. There is a 602 frame which is rated 7½ horsepower. The mounting dimensions and the dimensions of the shaft extensions remain unchanged for a given frame size. These dimensions for the old AISE number 6 frame are the same as for the new 606 frame. The new line will be available with or without back axles. Where back axle parts are provided the dimensions will be the same for a given size of frame. It should be noted that the size of shaft formerly used on the number 8 frame and which carried 25 horsepower now will be used on the 608 frame and will be rated 35 horsepower. The same minimum pitch diameter of pinions and the same gear ratios will be used for a given frame size. This increase of loading of the pinions partially will be compensated for by using a 20-degree stub tooth which has a greater capacity than had the old 19-degree involute shape of tooth. It long has been recognized that the diameter of the shaft extensions was excessively large on the old line for the ratings. Increasing the rating of the shaft brings it up more nearly in line to what it should be for a good design.

The size of bearings in a given frame are the same and in some instances are larger than in the old line. The increased rating per frame was accomplished by using a larger armature. In fact the new armatures are equal in size to those of the same rating in the old line. In other words, it may be said as a general statement that the armature formerly in the old 10 frame is now in the new 608 frame. This cannot be taken literally as the armatures have been redesigned for a better proportion of core diameter to length. The saving accruing from the use of a solid narrow bearing permits the use of the longer armature in a given frame. Changing the commutating poles from two to four permits an improved utilization of the field coil space. The field coils are reduced radially and widened circumferentially. This permits an armature with a greater diameter in a given frame. Changing from two commutating poles to four increases the range of black commutation and results in less maintenance of the commutator and brushes.

In addition to the motors being more compact and requiring less space, the new designs incorporate the most modern practices and have many features in them that result in a much improved motor over the present line.

CRANE APPLICATIONS

A review of those characteristics of modern mill-type series wound d-c motors which must be considered for correct application to crane drives were reviewed in a conference paper, "Selection of D-C Series Motors for Crane Applications," by M. A. de Ferranti (M '43) General Electric Company, Schenectady, N. Y. Particular attention was given to the recently standardized AISE d-c mill motors and the speed, torque, and duty cycle ability of this

motor was discussed in some detail. For the hoisting motion of cranes, the minimum rating of d-c series wound driving motor and the correct gear ratio is selected by use of the speed-torque characteristic curve. The subject of light hook speeds was reviewed and the effects on this of various ratings of motors discussed.

Factors which affect the selection of d-c series wound motors for bridge and trolley drives on cranes also were reviewed, and a method developed and the formula given for selecting the minimum rating of d-c series wound driving motors for bridge and trolley drives. Data were tabulated for the use of this formula within the practical limits of rolling friction and accelerating rates. A brief review with speed-torque diagrams was given for the various methods of connecting the d-c series wound motor to adapt it to hoist, bridge, and trolley drives of cranes, and examples for the selection of hoist and bridge motors were given to demonstrate the discussion in the paper.

"ELECTROFLUID DRIVE"

"Electric Drives with Fluid Couplings for Material Handling Equipments," was presented by Fred W. Atz, Link-Belt Company, Philadelphia, Pa. This paper discussed the "Electrofluid Drive," a new type of drive, made into a compact integral unit, which combines a standard general purpose motor with a fluid coupling. It is a highly efficient device, the fluid coupling consisting of two main elements, impeller and runner, which transmits power entirely by the mass and velocity of moving oil between the two elements. The combined unit, motor and coupling, mounted in a cast iron housing, meeting NEMA (National Electrical Manufacturers Association) motor dimensions, forms a packaged unit ready for operation. Beyond the small horsepower ratings, up to and including NEMA frame 364, the size and rating of the fluid coupling is unlimited so that it can be designed and built in any individual unit or development for standardized equipment. The object of the drive is to assure smooth operation eliminating shock loads, impacts, torsional vibration, and strains to the driven load. Use of the drive also is said to produce smooth acceleration, afford protection to the electric motor, and its use utilizes the maximum torque of the driving motor and limits stalled torque value.

Discussion of Subject of Switchgear Occupies Two Winter Meeting Sessions

With a combined program of seven technical papers, the subject of switchgear covered two Tuesday sessions of the 1948 winter general meeting. H. J. Lingal (M '41) Westinghouse Electric Corporation, East Pittsburgh, Pa., presided at both the morning and afternoon sessions.

MATHEMATICAL STUDY

"A Study of A-C Arc Behavior Near Current Zero by Means of Mathematical Models" (48-23), presented by T. E. Browne (M '45) of the Westinghouse Electric Corporation, East Pittsburgh, Pa., developed arc model equations to represent properly the known behavior of dynamic arcs. The basic equation for arc conductance, based upon power input to the arc, power loss from the arc, and time is expanded and applied to particular parts and special cases of arcing. Because this study concerns the arc column alone, it may be applied only to interrupters employing long arcs, such as gas-blast and magnetic-blast circuit breakers, expulsion fuses, protective gaps, and long power arcs in the open air. This or similar models also may be used for the mathematically more difficult investigation of the mutual interaction between the arc and the circuit, as well as for obtaining a better understanding of circuit interruption phenomena and the resultant sounder design, rating, and application of circuit interrupting devices.

COMPRESSED AIR CIRCUIT BREAKER

The inability of one piece of equipment to perform the functions of switching, protecting, and controlling high-voltage frequently de-energized circuits prompted the development of "A Compressed Air Circuit Breaker for 23-Kv Arc Furnace Duty" (48-24). This paper by H. M. Wilcox (M '27) and B. P. Baker (M '41), both of Westinghouse Electric Corporation, stated that an intensive series of tests of the new compressed air circuit breaker has demonstrated that with its strong shock-resistant construction and with all parts designed for highly repetitive duty, it is capable of withstanding many thousands of operations in the current ranges of magnetizing, load, and secondary fault currents, when operated at normal shop air pressure. Nonlinear resistance surge suppressors connected across the circuit breaker terminals reduce surge voltages to less than 40 per cent of their normal free value.

ARCING FAULT CURRENTS

The variations of fault currents caused by arc drop compared with fault currents predicted on the basis of a "bolted" fault, has been the subject of extensive tests and was described in the paper, "Arcing Fault Currents in Low-Voltage A-C Circuits" (48-26), by C. F. Wagner (F '40) and L. L. Fountain (M '45) of the Westinghouse Electric Corporation, East Pittsburgh, Pa. Though the drop across an arc is quite variable, it is an appreciable fraction of the circuit voltage and therefore is reflected in the magnitude of the current. It was found that on 250- and 125-volt a-c circuits, arcing faults are unstable and will extinguish themselves within two cycles or less (with 4-inch bus spacing). The 500-volt faults were also unstable and extinguished themselves in about half of the tests. Curves of arc drop versus average current and line voltage were plotted and indicated that the sustained current may be less than 0.810 of the bolted symmetrical current.

OIL CIRCUIT BREAKER

The possibility of short-circuit powers approaching 15,000,000 kva at Grand Coulee Dam, Wash., has fostered the development of "A 230-Kv 3-Cycle Oil Circuit Breaker for Extra-Heavy Arc Rupturing Duty" (48-40). The design and testing of this circuit breaker was described in a paper by W. M. Leeds (M '38) and G. B. Cushing (A '40), both of the Westinghouse Electric Corporation, East Pittsburgh, Pa. With 1,000-ampere continuous-current rating, this circuit breaker is suitable for interrupting duty between $7^1/_2$ and ten million kilovolt-amperes with 3-cycle interrupting time, and 20-cycle reclosing duty cycle. The 84-inch diameter steel tank already in use was adequate for the new design. The multiflow De-ion grid-type interrupter has been redesigned for high-capacity duty. Part-by-part tests were performed in the laboratory and correlated with field tests to determine the operating characteristics and capacities of the new circuit breaker.

TEST RESULTS

Field tests of impulse-type and tank-type circuit breakers at Grand Coulee Dam, Wash., to determine the practicability of manufacturing 10,000-megavolt-ampere circuit breakers were described by E. B. Rietz (A '42) of the General Electric Company, Philadelphia, Pa., in his paper "Unusual Performance of Standard 230-Kv Impulse- and Tank-Type Oil Circuit Breakers on Field Tests" (48-41). The interrupting performances of both circuit breakers was quite remarkable in that they interrupted nearly twice their rating with no evidence of distress and no indication that they had reached their limits. Impulse-type oil circuit breakers seemed best to interrupt line chargings currents, but multibreak interrupters can be combined with suitable resistors to give satisfactory performance. It was concluded that field tests must be used in the development of heavy-duty circuit breakers and that large laboratory test facilities are not necessary.

A complimentary description of field tests on four types of circuit breakers at Grand Coulee Dam, Wash., was entitled "Field Tests for Development of 10,000,000-Kva 230-Kv Oil Circuit Breakers for Grand Coulee Power Plant" (48-42), by C. L. Killgore (M '47) United States Bureau of Reclamation, Denver, Colo., and W. H. Clagett (M '46) United States Bureau of Reclamation, Coulee Dam, Wash. A detailed description of the test equipment and arrangement was given. Test results were given in tabular form. Conclusions were essentially the same as those reached in the previous paper.

Award winners E. M. Williams (A '40) Carnegie Institute of Technology (left) and J. M. Wallace (A '41) Westinghouse Electric Corporation (right) with AIEE President B. D. Hull at the Eta Kappa Nu Recognition Awards dinner on Monday, January 26

"Performance Tests of the Allegemeine Elektricitäts Gesellschaft Free-Jet Air-Blast 2,500-Megavolt-Ampere Reclosing Circuit Breaker" (48-43), by Alexander Dovjikov (M '41) and Clifford C. Diemond (M '45) of the Bonneville Power Administration, Portland, Oreg., described the construction and operation of a representative sample of a 50-cycle German circuit breaker as tested on an American power system. Although the speed of fault-current interruption of this circuit breaker is not as good as the best of American oil circuit breakers, its simplicity, ease of maintenance, freedom from use of oil and resultant oil maintenance and handling, freedom from fire, and general performance prompted tests to determine the possibility of incorporating these features in a faster American prototype which also would be practically free from restrikes in interrupting line charging currents. Although an improvement in arcing time (1.4 to 2.9 cycles) may be difficult, it appears that the time to part the contacts (3.6 cycles) may be shortened. The characteristics of the circuit breaker while interrupting line-charging currents were particularly poor, but redesign of the interrupter head to utilize the insulating qualities of the high-pressure air available probably would correct this. Incidental to the data obtained on the circuit breaker operation, it was found that 8 cycles minimum reclosing time must be allowed for 3-pole operation and 17–20 cycles for single pole operation.

Electronics Discussed at Tuesday Session

Under the chairmanship of C. H. Willis (F '42) Princeton University, Princeton, N. J., a technical session on electronics was held on Tuesday, January 27. Four technical papers were presented.

THERMIONIC GAS TUBES

V. L. Holdaway (A '31) of the Bell Telephone Laboratories, New York, N. Y., discussed the advantages to be obtained from "Quadrature Operation of Filamentary Thermionic Gas Tubes" (48-32). Laboratory tests have proved that when the anode and filament voltages are inphase, a marked temperature gradient exists along the filament which considerably may shorten the life and reduce the reliability of the tube. However, if the filament is operated line-to-line on a 3-phase power supply and the anode voltage taken from line to neutral, the resultant quadrature phase relations produce symmetrical heating and cooling effects in the tube filament ends. Although laboratory tests have not been completed, all indications point to the fact that not only can longer life be expected from tubes operated in this manner, but also higher peak anode current can be tolerated.

MEASUREMENT METHOD

"A Method for the Measurement of the Ionization and Deionization Times of Thyratron Tubes" (48-33), was described by Milton Birnbaum of Washington, D. C. Because no method yet has been devised for computing these quantities, their accurate measurement is a great aid in designing pulse- and trigger-type circuits. Ionization time measurements are determined by measuring the difference between starting time of a rectangular triggering pulse and the thyratron pulse. The rectangular pulse is obtained from a 4-element thyratron operated in conjunction with a charged delay line. The ionization time measurements were tabulated in the form of time versus voltage-required-to-reignite. Variation of deionization times with tube type, peak current, grid resistance, anode voltage, control grid bias, control grid and shield grid biases, and ambient temperatures were shown.

PRINTED CIRCUITS

Cledo Brunetti of the National Bureau of Standards, Washington, D. C., described "Printed Circuit Developments" (48-34), by discussing the principal method of printing electronic circuits (painting, spraying, chemical deposition, vacuum processes, die stamping, and dusting) and their subdivisions. Many of these methods have been proved in practice on production lines. Although not all the components of an electronic circuit can be printed, the practice has been adapted successfully to conductors, resistors, capacitors, inductors, shields, and antennas. Clever design and utilization of essential standard components enabled miniaturization in some applications which is unattainable by other means. Another advantage of printed circuits to the manufacturer is their tendency toward "tamper-proofness." Present printed assemblies on the market in general have been found to cost no more, and in most instances less, than present units using conventional methods of production. With continued development, the printed circuit technique probably will reflect considerable saving.

IGNITRON RECTIFIERS

"Performance of Pumped Ignitron Rectifiers" (48-35), was analyzed in a paper by C. C. Herskind (M '40) and E. J. Remscheid (M '40) of the General Electric Company, Schenectady, N. Y. Although nonuniformity and lack of performance records make comprehensive analysis of rectifier performance difficult, certain conclusions can be drawn after examining existing performance data. Arc-back, although frequent and detrimental in early installations, now can be limited to less than one or two per rectifier per year. Ignitors now in production have an average life expectancy exceeding five years. A proposed definition of "reconditioning" was offered to limit the use of the word to complete overhauling. Ignitrons incorporating the latest improvements can be expected to operate more than five years without reconditioning. It has been found that corrosion of the cooling systems can be eliminated by adding anhydrous sodium chromate to the recirculating water. Continuous preventive maintenance is extremely important in obtaining reliable and continuous service from pumped ignitron rectifiers.

Tuesday Symposium Held on Railroad Electrification

A symposium on railroad electrification was held on Tuesday, January 27, of the AIEE winter general meeting in Pittsburgh. J. C. Aydelott (M '32) General

Electric Company, Erie, Pa., was chairman at this session.

QUESTION OF COSTS

Llewellyn Evans (F '41) of the Tennessee Valley Authority, Chattanooga, Tenn., analyzed "Power Costs and the Contribution of Existing Transmission Networks Toward Cost Reduction of Power For Electrification of Main Line Railroads With Moderate Traffic" (48-97). It was assumed that the 330-mile double track railroad described in the next paper traversed the territory of three utilities and that there were four stations for a 25-cycle a-c system or 6 stations for a d-c supply system. Results show that the total cost of power is of the same order as the capital charges for the track-side construction and substation as presented in the next paper on the program. The average price of power varies from 0.5 cent to 2 cents per kilowatt-hour, depending on the load factor of the individual stations and the source of power. Combination of demand metering points cost twice as much as the extra demand charges at the original supply points. Most likely operating conditions of this railroad indicate an annual average rate of 0.884 cent per kilowatt-hour for 100 per cent traffic and 0.686 cent per kilowatt-hour for 157 per cent traffic. Possibly 10 per cent lower cost could be earned by careful dispatching of locomotive operation, but much higher cost could result from train schedules and dispatching which disregards system peaks.

The next paper, "Electric Locomotives With Identical Basic Components" (48-54), by W. A. Brecht (A '39) and Charles Kerr, Jr., of the Westinghouse Electric Corporation, East Pittsburgh, Pa., emphasized the fact that standardization of locomotive components would lower first costs of electrification of railroads. The requirements for a modern locomotive were listed as: high availability, standardization and low first cost, low operating and maintenance costs, good tracking qualities, light axle loads, sustained output over the entire speed range, large starting tractive effort with entire locomotive weight on drivers, high continuous tractive effort, and an adhesive weight of approximately 100 pounds per continuous rail horsepower. In addition to meeting these requirements, an electric locomotive should be capable of being built in one cab for any capacity required and should permit installation of both a-c or d-c equipment. Such a series of locomotives of varying capacities to fill every motive power need has been designed. Standard 469-rail-horsepower trucks can be combined in different numbers to form single-cab locomotives of capacities up to 10,000 maximum rail horsepower. Each axle will be loaded to only 45,000 pounds. The proposed standard 4-wheel truck will be of the "no-lift" lateral motion type. Switching, freight, or passenger service characteristics are obtained by the selection of the proferred gear ratio. Ventilation, braking, and control units will vary in size but be composed of identical component parts. A weight ratio of approximately 100 pounds per continuous rail horsepower is maintained throughout the entire line, enabling operation of any or all combinations in multiple. Cost data were given which indicated that the proposed electric locomotive can sell for a little over half the price of a comparable Diesel locomotive. Operating and maintenance expenses also are reduced by this standardization.

OVERHEAD DISTRIBUTION COSTS

L. W. Birch (M '29) of the Ohio Brass Company, Mansfield, Ohio, answered the question, "Are the Overhead Distribution Costs Retarding Railroad Electrification?" (48-38), by stating that the high first costs of electrification do not result entirely from the cost of the overhead distribution systems. However, blanket reduction of first costs would enable comparable initial cost for electrification and Dieselization. Suggestions were made for economies in the installation of overhead distribution systems. Work train costs could be cut by intelligent planning and use of additional off-track equipment. Elimination of duplicate designing by the engineering department and the manufacturer would eliminate much of the engineering cost. Intelligent planning and scheduling of material deposition would save in storage and labor costs. Economies can be effected in the choice of materials and auxiliary equipment. Clearances demanded by the operating departments are expensive to supply, and perhaps could be compromised upon. Examples were given where 10 to 15 per cent could have been saved on the distribution system installation.

A theoretical, but typical, 2-track railroad of moderate traffic density has been used for the determination of "Railroad Electrification Energy Conversion and Transmission Costs" (48-37), by R. L. Kimball (A '36) and J. G. Holm (M '29) of Gibbs and Hill, New York, N. Y. The a-c system chosen for analysis was single phase 24 kv with rotating frequency changes to convert from 60-cycle to 25-cycle power and with either 85 per cent lagging or 95 per cent leading power factor utilization equipment. The d-c system chosen was 6 kv, with metal-tank mercury-arc rectifiers for conversion. Though an individual study must be made to determine the practicability of electrifying any specific system, these typical calculations indicate that for railroads of moderate traffic density either d-c or a-c electrification, including both energy conversion and transmission, is of reasonable cost. The heavier the traffic or the grades, the more economical electrification becomes. By means of power interchange between conversion stations, spare frequency-changer capacity may be reduced to approximately one unit on the entire system. The 95-per-cent leading power factor a-c system proved to be more economical in annual costs. Higher feeder and trolley voltages may produce further savings where their use is possible.

The economies of d-c electrification will increase if rectifier and other equipment costs decline with further development as seems probable.

Electrical Application Discussed in Machine Tool Session

Four conference papers covering various electrical engineering applications in the machine tool industry provided the subject for a machine tool session on Tuesday afternoon, January 27, at the AIEE winter general meeting which was held in Pittsburgh, Pa.

W. E. Wigton (A '40) The Cincinnati Planar Company, Cincinnati, Ohio, who presided at the machine tool session, presented a paper called "Electrical Engineering in the Machine Tool Industry." The paper pointed out that though in the late 1920's and the early 1930's the electrical engineer in the personnel of a machine tool company was a rarity, since the increased electrification of the machine tool industry the electrical engineer has been playing a more important role. The author indicated a bright future for electrical engineers in the machine tool field. However, this was contingent upon the continued price increases of electric motors and controls. It was pointed out that such a trend would do much to "kill the goose which lays the golden egg." Electrical engineers are finding increasing work in fields such as development, research oscillographic studies, strain analysis, equipment specification, and purchasing. In some companies, electrical engineers, because of their knowledge of circuit analysis, are becoming hydraulic engineers after additional training. Some electrical engineers also are finding their way into the sales departments of machine tool companies.

ADJUSTABLE SPEED MOTOR CONTROL

Recent advances in the field of machine tool drives in the form of wide range adjustable speed motors and the metallic rectifier as a source of power supply for adjustable speed motors were discussed in a paper called "New Types of Adjustable Speed Motors for Machine Tools," by Uno M. Elder, of the Westinghouse Electric Corporation, East Pittsburgh, Pa. Speed adjustment of eight-to-one has been attained by a new method which eliminates the poor commutation, high regulation, and inconsistant speeds on repetitative operation which results from weakening the fields of a standard d-c motor. A 2-circuit armature and independent excitation of poles are employed. By maintaining independent poles at stronger values and reversing two poles, a low effective flux and a high speed is obtained. This system provides more flux per pole at high speed, resulting in a flatter speed regulation curve. Metallic selenium rectifiers for operating adjustable speed d-c motors have been developed in six sizes up to 15 horsepower, which combine higher power factor and over-all efficiency with about the same voltage regulation afforded by comparable motor generator sets. Motors up to $7^1/_2$ horsepower may be line-started through the rectifier, thereby eliminating all d-c controls except the field rheostat.

PLANER DEVELOPMENT

Before the invention of the Roberts planer in 1817, the production of accurate plane surfaces was almost impossible. The progression of the metal planer to its present high level of development was traced by J. W. Harper, of the General Electric Company, Schenectady, N. Y., in his paper, "Planer Drives—Their History and Application." The reversing motor drive has helped establish the rate of production now possible. Its modern refinement, the adjustable voltage drive, particularly is suited to driving planers because of its wide speed range, ample torque capacity, simple control, safety, and reliability. A modern drive consists of seven parts: the planer motor, the motor-generator set and its starter, the main controller, the rheostat for cut and return speed adjustment, the limit switch, and the pendant push-button station. These components must be designed to function together as a unit to get the most production out of the planer for which they furnish the power. The use of this type of drive also makes possible a reversing motor drive for small planers where previously only belt-driven machines could turn out the necessary production. While the adjustable voltage drive is more expensive than most other drives, when considering it as a component part of the machine and drive, the increase can be justified readily by the increased production.

PERFORMANCE ANALYSIS OF SHARPENING MACHINE

The co-ordination of mechanical, hydraulic, and electric controls and operating mechanisms have been analyzed critically to speed up and simplify the process of sharpening form relief tools. The method of analysis and interpretation of data was described in the paper, "Electrical Features and Oscillograph Performance Analysis of an Automatic Sharpening Machine for High-Speed Steel and Carbide Hobs and Form Relief Tools," by R. E. Johnson (F '45) and F. A. Glassow (A '46), of the Barber-Colman Company, Rockford, Ill. The electrical testing technique, using a simple 3-element magnetic oscillograph to record simultaneously data to determine the instant of operation of five critical parts and the position and velocity of two other major parts of the sharpener, is of interest to development engineers in the machine tool and allied fields.

C. A. Powel (F '41) past president of the AIEE and chairman of the general committee for the winter general meeting (left) and AIEE President Blake D. Hull at the general session on Wednesday morning

Telemetering is Subject of Technical Session

Three technical papers on telemetering were presented at a session on Tuesday, January 27. Chairman at the session was G. S. Lunge (A '23) General Electric Company, Schenectady, N. Y.

THE PROBLEM

Seldom is an engineer allowed to design and install a complete telemetering system without regard to its adaptation to some equipment already in use. Such a situation prompted the investigation of reliable low-cost systems which would meet the demand of a particular installation. The results of this research are described in "The Problem and Telemetering Systems Considered" (48-45), by R. G. Meyerand (M '37) of the Union Electric Company of Missouri, St. Louis, Mo. Wartime scarcity of personnel necessitated a telemetering system for indication of plant system loads. It was decided that provision should be made for later addition of var indication, combination of plant load indication in geographic and system totals should be possible, individual and totalized kilowatt-hour and integrated demands should be obtainable, provision should be made for zero center indication for frequency changers and tie lines, operation of remote indicators from any of the transmitters or receivers should be provided, and total system load indication should be transmitted back to certain plants. A combination of carrier transmission over double-circuit transmission lines, leased telephone pairs, and company-owned signal circuits were used to form the telemetered networks. Frequency-division multiplex is used to provide ten audio tone channels, only eight of which are used at present. The load dispatchers' desk is used as the centralized point for the collection of readings. Retransmission of the data to the operator's desk of large generating stations enables the operator to get a composite view of system conditions at all times as related to his own plant.

FASTER TELEMETER

The design and application of a frequency-type telemeter transmitter and receiver were described in "A Faster Telemeter for Carrier-Current Channels" (48-46), by E. E. Lynch (M '35), H. C. Thomas (M '47), and G. S. Lunge, all of the General Electric Company, Schenectady, N. Y. By means of a light source, serrated disk, and a photoelectric tube, the rotation of a wattmeter (or other torque-balanced converter) may be translated into a constant amplitude current whose frequency varies from 6 to 27 cycles per second. This signal can be fed through suitable impedance matching devices and amplifiers to the carrier channel transmitter. Amplitude modulation or frequency shift modulation may be used. Various types of multiplexing can make possible the transmission of several signals over one carrier channel. The receiver consists primarily of a coupling transformer, a filter network, a limiting amplifier, and a power amplifier. The primary detector itself is a saturating transformer and rectifier, the secondary output of which has an average value dependent only on the frequency of the input signal. This new telemetering system has many advantages: instantaneous response without overshoot, a higher degree of accuracy, stability of calibration, precision, continuous transmission of signal (thereby avoiding the necessity of a decision as to whether there is no reading or the system is out of order), and suitability as a component of an automatic control scheme, a totalizing or integrating system. The flexibility of application was illustrated by the authors with examples. In addition to metering watts, vars, alternating amperes or volts, and totalizing, the basic system is also applicable for telemetering direct milliamperes or millivolts, forebay water level, and mechanical position.

NEW DEVICES

The concluding paper, "New Devices Derived From a Torque Balance Telem-

eter" (48-44), was presented by W. H. Burnham (Membership Application Pending) of the General Electric Company, West Lynn, Mass. Two new devices based upon and designed to work in conjunction with the torque balance telemeter provide the additional functions of signaling, totalizing, and integrating. The basic torque balance telemeter unit was described as a torque mechanism energized by the quantity to be measured, and a restraining mechanism energized by feedback of output signals. Both mechanisms are mounted on a single shaft, the angular position of which determines the amount of light reflected by a mirror upon each of a pair of photoelectric tubes. The difference of the current of the photoelectric tube constitutes the d-c signal. The torque balance load injector replaces the operating mechanism by two instrument control springs which may be regulated manually by a knob. The power supply was redesigned to provide increased output current. This device may be used to substitute an average reading in the values to be totalized when a channel is out of operation. By calibrating the instrument scale in units of loads and placing it in a generating station, the load dispatcher may signal the load to be carried at any time. The torque balance converter is a method of integrating incoming signals with respect to time. A wattmeter mechanism is used as the operating mechanism and a d-c milliammeter constitutes the restraining mechanism. The photoelectric tubes are replaced by variable ratio transformer mounted on the shaft, the ratio of which is determined by the angular position of the shaft. The output signal is amplified by current amplifier and sent into a watt-hour meter for totalizing. This instrument can be used to totalize any quantities which can be converted into watts.

Tuesday Session Considers High-Frequency Measurements

F. J. Gaffney (A '37) P.I.B. Products Company, Brooklyn, N. Y., presided at a session on January 27 on the subject of high-frequency measurements. The program comprised four technical papers.

D-C BRIDGE

The application of bolometers to microwave power measurements was described in the paper "A Direct Reading D-C Bridge for Microwave Power Measurements" (48-47), by Herbert J. Carlin (A '41) and Judd Blass of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Utilization of the resistance change of a bolometer element with change in power, independent of the type of excitation, in a Wheatstone bridge was analyzed. Either d-c or audio power may be used to balance the bridge and compensate for the resistance change in the bolometer arm caused by the power fed to it. Design considerations were discussed and rigorous mathematical analysis was given to bridge operation, bridge design, broad band bridge operation, and meter sensitivity.

BROADBAND SIGNAL GENERATOR

A calibrated source of signal power in the 4,200 to 10,300 megacycles per second range was described in the paper, "A Broadband Signal Generator" (48-48), by Thomas P. Hahn, John Ebert, and W. A. Lynch, of the Polytechnic Research and Development Company, Brooklyn, N. Y. Three klystrons are used to supply approximately 100 milliwatts of energy to the attenuator through a coaxial line switch and a matching transformer. The switch is a modified 6-pole 6-throw radio-frequency coaxial line switch and applies beam voltage to the desired tube and completes the radio-frequency connection to the coaxial line system. The attenuator is of the wave-guide-below-cutoff type supporting TE_{11} as the principal mode. Small metal-coated glass tubes are used as power launching and pickup elements. Because the resistive nature of the metallic films is a function of the radio-frequency power, the launching element is used as one arm of an a-c bridge circuit to make a broadband matched power monitor bolometer element which provides the power output calibration. Provisions are made for both continuous wave and pulse operation.

NBS METHOD

The method adopted by the National Bureau of Standards for "Microwave Frequency Measurements and Standards" (48-49), was described by Benjamin F. Husten and Harold Lyons (M '47) of the National Bureau of Standards, Washington, D. C. Operating over a range of 300 to 30,000 megacycles per second, provision is made for continuous frequency coverage accurate to one part in ten million, as well as for the generation of spot frequencies accurate to within one part in 100 million. The microwave frequencies are obtained from the National Bureau of Standards' 100-kc frequency standards through a system of frequency multiplication, frequency conversion, and harmonic selection. Sensitive spectrum analyzers or superheterodyne receivers with panoramic adapters are used in indicating equipment. Mathematical analysis of the accuracy of calibration, frequency pulling by external reactance, and effects of temperature, humidity, and pressure were presented.

CALIBRATION METHOD

A method of calibration of commercial attenuators over the entire microwave frequency range was described by "A Standard of Attenuation for Microwave Measurements" (48-50), by R. E. Grantham and J. J. Freeman, of the National Bureau of Standards, Washington, D. C. The heterodyne or intermediate-frequency substitution method is used to enable one standard attenuator, operating at a convenient frequency, to be used in the calibration of attenuators over the entire microwave spectrum. By this method, the output of a radio-frequency generator is fed through the unknown attenuator into a linear frequency converter. This output intermediate frequency energy passes through an intermediate frequency standard attenuator into an amplifier, followed by a detector and meter. When the unknown attenuator is removed from the circuit, the standard attenuator is adjusted to give the same meter reading, the increased attenuation being equal to the value of the unknown attenuation. Linearity of the frequency converter is of prime importance in this application and is supplied by a crystal converter. The standard attenuator is a circular-wave-guide below-cutoff 20-megacycle attenuator using the TE_{11} mode and having an attenuation of 21 decibels per inch. Rectangular input and output coils mounted on precision-made bakelite forms are used to secure symmetry and reduce the unwanted modes. Filters also may be used to attenuate unwanted modes. An accuracy of plus or minus 0.2 per cent of the attenuation value is expected in the 10- to 50-decibel range and an accuracy of plus or minus 0.02 decibel below this range.

Tuesday Session Covers Subject of Heavy Traction

With J. C. Aydelott (M '32) General Electric Company, Erie, Pa., presiding, a winter general meeting session on Tuesday, January 27, was devoted to the subject of heavy traction.

OPERATING RESULTS

More than 20 years experience by the Great Northern Railway with various types of locomotives has enabled Joseph F. N. Gaynor, Wenatchee, Wash., to present "Comparative Operating Results of Steam, Diesel-Electric, and Electric Motive Power on the Great Northern Railway Electrification" (48-36). The single-phase 25-cycle 11-kv electrification system of this mountain district has provided economies in time, crew costs, increased train tonnages, and reliability. Wartime operation of several types of locomotives over the same lines enabled valuable comparisons to be made. Standardization of electric motive equipment would be a great aid in maintenance and operation of electrified and semielectrified railroads.

SHUNT CAPACITOR INSTALLATION

The first installation of its kind was described in "Shunt Capacitor Installation for Signal-Phase Railway Service" (48-39), by H. F. Brown (F '47) of the New York, New Haven and Hartford Railroad, New Haven, Conn., and R. L. Witzke (M '45, of the Westinghouse Electric Corporation, East Pittsburgh, Pa. After a comparison of the merits and economics of synchronous condensers and shunt capacitors, it was decided to install eight individual units of approximately 1,250 kva each in outdoor housing as near the load center as was practical. The capacitors are switched in 2,500-kva steps and are protected by overvoltage and undervoltage relays. Series reactors are used to tune the installation for control of both the third and fifth harmonic voltages on the traction system. The entire capacitor station cost was

less than $23 per installed kilovolt-ampere. In addition to raising the trolley–rail voltage on the eastern end of the system by at least 2,000 volts during peak load conditions, an estimated 6,000 kw of generating capacity was released, power used in the operation of frequency changers as synchronous condensers was eliminated, and transmission losses were reduced.

WHEATSTONE BRIDGE

A refinement of the Wheatstone bridge for indicating the condition of electropneumatic brake control circuits was described by C. M. Hines (M '45) of the Westinghouse Air Brake Company, Wilmerding, Pa., in his paper, "A Unique Application of the Wheatstone Bridge to High-Speed Train Braking" (48-53). By using two relays alternately to short-circuit one-half of the bridge network and a third relay to replace the conventional galvanometer, any change in resistance of either half of the circuit can be interpreted as being a fault either on the brake control circuit or the Wheatstone bridge circuit. Indication of a fault enables the engineman to switch from electropneumatic brakes to conventional pneumatic brakes before the application of the brakes is necessary. The equipment may be set to operate satisfactorily with trains varying in length from 1 to 24 vehicles. Two bridges are used, one for checking the application wire circuits and the other for checking the release wire circuits.

SPEED-RESPONSIVE DEVICES

A new means of automatically selecting Diesel-electric locomotive motor connections during acceleration and deceleration was described by A. V. Johansson (A '47) of the General Electric Company, Erie, Pa., in his paper "Speed-Responsive Devices on Diesel-Electric Locomotives" (48-52). A 14-pole permanent-magnet-rotor 3-phase Y-connected generator is attached to the end of one of the locomotive axles and acts as a tachometer. The generator energizes speed relays and the locomotive speed indicator. Each relay is energized through the medium of a tuned circuit; as the speed at which the relay is to operate is approached and the voltage across the relay coil increases very rapidly, an inherently accurate and stable relay operation is obtained. Drop-out speed can be set very close to the pickup value for any relay. Typical operating curves were given by the author to illustrate the use of the switching relays.

New Developments are Main Topic at Session on Electronic Devices

Some new electronic devices and applications were the basis for discussion at a session on Tuesday, January 27. W. G. Dow (M '32) University of Michigan, Ann Arbor, Mich., presided. The program for the session comprised five conference papers.

LARGE PULSE CURRENTS

"The Measurement of Large Pulse Currents," was the subject of N. Rochester and D. L. Stevens, of Sylvania Electric Products, Inc. Pulse currents as large as 30,000 amperes have been measured by a technique in which a low-loss inductor replaces the customary low-inductance resistor. The method was devised to measure the currents which result from the discharge of a capacitor through a short spark gap. The circuit must be underdamped but currents which are too large for resistors can be measured with ease. The theory and areas of usefulness of both the resistor and inductor methods were discussed and experimental results presented for the new method.

CATHODE-RAY OSCILLOGRAPHY

A discussion of "New Apparatus and Techniques for Cathode-Ray Oscillography," was presented by P. S. Christaldi, Allen B. DuMont Laboratories. The need for dual-channel oscillographic equipment capable of frequency response from zero to hundreds of thousands of cycles per second has been met by the design of a dual-beam cathode-ray oscillograph incorporating many novel features. Essentially, it consists of two individual cathode-ray oscillographs with extended-range d-c amplifiers for individual horizontal and vertical deflection of the two electron beams, together with sweep circuits that may be used individually or to provide a common time-base. Either recurrent or single sweeps may be used, thus making possible the study of related transient phenomena without the loss of information that results from time-sharing methods such as electronic switching. A built-in voltage calibrator facilitates making quantitative measurements. Limitations of performance that might be imposed by required manufacturing tolerances of dual-beam cathode-ray tubes have been overcome by the use of special circuits to compensate for differences in X-axis deflection factors and undeflected spot positions, so as to permit the exact superposition of time-bases when using a common generator and amplifier. Accelerating potentials of 4,500 volts provide adequate brightness or persistence over a wide range of single transient durations.

Improved techniques for the study of rotating or reciprocating machines are possible by the use of a new polar-co-ordinate cathode-ray indicator. A 2-phase alternator attached to a shaft of the machine is used to generate a circular time-base in constant phase relation over the rated speed range of the equipment. Thus even instantaneous speed changes of the shaft during a single rotation do not change the relative locations of signal indications along the circular time-base. Radial deflection is produced by modulating the gain of the X- and Y-axis amplifiers simultaneously, and this permits the use of conventional orthogonal deflection types of cathode-ray tubes rather than of radial deflection types, which have many electrical and mechanical limitations. The wave form of the phenomenon to be studied, such as vibration, pressure, brush noise, or the output of a switch, photoelectric or magnetic pickup actuated by the device under study, may be applied to the radial deflection amplifier to produce the indication. The indication thus appears as a radial deflection from the circular time-base, and its angular timing may be measured directly. If so desired, beam intensity modulation may be used to provide additional marking or other information. Equipment of the type described has been used successfully in the adjustment of textile looms, in the study of brush noise and vibration in rotating machinery, the analysis of fuel injection and ignition in engines, and in many other fields.

In many instances, photographic recordings of oscillograms are desirable for analysis and record purposes. This is facilitated by the introduction of two cameras especially designed for oscillographic recording. The first of these is a still camera using 35-millimeter film and having a fixed focus, coated f:3.5 lens, and a shutter having time, bulb, and 1/30-second exposures. Selection of film size and lens and shutter characteristics was made to provide the maximum photographic capabilities consistent with reasonable cost of both camera and film. Spot writing speeds ranging up to about 30 inches per microsecond easily may be recorded with the camera, used in conjunction with various oscillographs now commercially available.

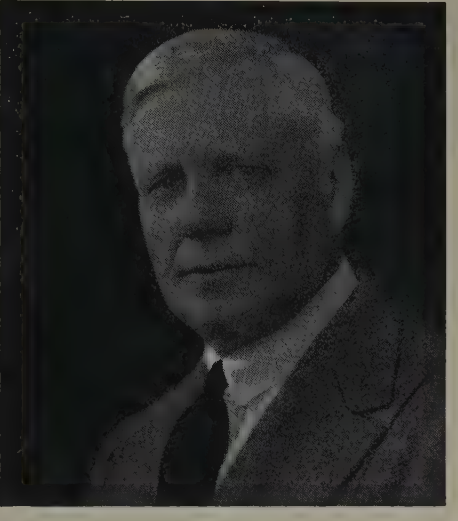
The second type of camera described was designed for either moving film or single frame recording, to facilitate the study of slowly varying phenomena as well as to provide a long time-base for the study of rapidly varying phenomena which are nonrecurrent in nature. The starting and hunting characteristics of a synchronous motor, for example, may be recorded and studied in detail on an extended display. Biological potentials may be recorded over periods of several minutes or several hours. The camera uses an f: 2.8 lens and has a wide range of shutter speeds. The 35-millimeter film is used and film speed is variable electronically over the range of one inch per minute to five feet per second with continuously variable calibrated control, and with speed constant for any setting to within five per cent. Single frame exposures may be made by means of a manual film advance and are particularly useful in connection with an illuminated data card on which may be written information pertinent to each recording.

PHOTOCONDUCTIVE CELL

"The Lead Sulfide Photoconductive Cell," described by R. W. Engstrom,

In Memoriam

CUMMINGS C. CHESNEY



THE board of directors of the American Institute of Electrical Engineers records, with keen regret, the death on November 27, 1947, of Cummings C. Chesney, 39th president of the Institute, and a pioneer in the development of a-c machinery and high-voltage power transmission.

He was born in Selinsgrove, Pa., on October 28, 1863, and was graduated from Pennsylvania State College in 1885. After teaching mathematics and chemistry at the Doylestown Seminary for three years, he spent one year in the laboratory of William Stanley in Great Barrington, Mass., and then was employed by the United States Electric Lighting Company, Newark, N. J.

He was one of the incorporators, in 1890, of the Stanley Laboratory Company, Pittsfield, Mass., and upon the organization of the Stanley Electric Manufacturing Company, in 1893, he became vice-president and chief engineer. Mr. Chesney and his colleagues developed the SKC system of polyphase power transmission.

When the General Electric Company acquired the Stanley Company in 1906, Mr. Chesney became manager and chief engineer of the Pittsfield works, in which position he continued until 1927. He served several years as vice-president and chairman of the manufacturing committee, and upon his retirement was designated honorary vice-president.

Mr. Chesney joined the Institute in 1894, and was transferred to the grade of Member in 1899, and to the grade of Fellow in 1913. He was elected an Honorary Member in 1938. He was a director, 1905–08, a vice-president, 1908–10, and president, 1926–27. He received the Edison Medal for 1921 "for early developments in a-c transmission." His interests were broad, and he was a director of several insurance companies, a railroad company, and two banks.

Resolved: That, upon behalf of the membership, the board of directors expresses its appreciation of Mr. Chesney's active and long-continued interest in Institute affairs, and its deep regret at his death.

And be it further resolved that these resolutions be transmitted to members of his family.—*AIEE Board of Directors, January 29, 1948.*

Radio Corporation of America, Lancaster, Pa., was developed in the United States during the war for infrared signaling and detection by R. J. Cashman. Its unusual sensitivity, and speed of response, compared with that of other infrared detectors, have accelerated the interest in peacetime uses of the cell. Possible application to 16-millimeter sound reproduction may eliminate exciter lamp voltage supply problems by allowing the substitution of an indirectly heated low temperature lamp. Many industrial temperature control devices become feasible by radiation measurement. Scientific measurements in the infrared to three microns are aided by the advantages of this detector. Specific properties of experimental RCA cells were discussed, such as: linearity; variation of sensitivity and noise with voltage; variation of resistance, frequency response, and signal to noise with temperature; effect of background illumination on cell sensitivity and noise. A brief discussion was given on some of the possible coupling circuits and matching problems.

DETECTORS

"The Motion Detector—an Application of Microwaves," was described by W. C. White (M '46) General Electric Company, Schenectady, N. Y.

All engineers are familiar with the physical phenomenon called the Doeppler effect. The classical experiment to show this with sound was to have two runners approach each other, one of them carrying a bell which he constantly is ringing. To the other runner as he approaches and passes his partner with the bell there is a distinct increase and then decrease in the pitch of the sound he hears. Everyone has experienced a similar effect while riding in a train when a locomotive passing in the opposite direction sounds its whistle.

The electromagnetic radiations called radio waves travel about one million times faster than sound waves. To compensate for this difference and thus utilize radio waves for the Doeppler effect, frequencies one million times as great can be used. During World War II this principle was used in what is now known as the VT or proximity fuse. Here the application involved airplanes, bombs, and shells traveling at hundreds of miles per hour. The proximity fuse is described in the September 1947 issue of *ELECTRICAL ENGINEERING* (*pp 888–93*).

As a result of important vacuum tube developments during the war we are now able to generate with simple vacuum tubes and associated circuits frequencies so much higher than used in the proximity fuse that we can apply this principle to objects moving only a few miles per hour such as persons walking or slow moving vehicles.

This application was described and demonstrated by a piece of simple portable equipment. This demonstration equipment operates a light or rings a bell when any small moving object up to a few yards away intercepts its beam of 2,450-megacycle microwaves.

"The Hydrogen-Diffusion Leak Locator," was presented by Herbert Nelson, RCA Victor Division, Harrison, N. J. A new instrument has been developed for locating leaks in vacuum devices and vacuum equipment. It employs a sealed-off, highly evacuated ionization gauge having a section of its envelope made of thin palladium sheet which, when heated, is highly permeable to hydrogen. In the instrument, the gauge is connected to an all-metal manifold with the palladium section isolating the vacuum of the gauge from that of the manifold. When a leaky vacuum device connected to the manifold is probed with hydrogen, leaks are indicated by an increase in the ion current of the gauge. As gases or vapors other than hydrogen do not penetrate the palladium, high vacuum is not required in the manifold nor in the device under test. A vacuum of the order of 1 to 10 microns is sufficient. The new instrument is similar to the mass-spectrometer leak locator in that it owes its high sensitivity to its ability to sort out, from other gases and vapors, the tracer gas (H_2) which enters through the leak. Thus, the palladium window in the hydrogen-diffusion leak locator serves the same purpose as does the crossed electric and magnetic fields of the mass-spectrometer leak locator.

Two Sessions on Power Consider Distribution in Various Industries

Two 1948 winter general meeting sessions were devoted to the subject of power distribution. The first, on power distribution in steel mills and mines, was held on Wednesday, January 28, under the chairmanship of D. L. Beeman (M '43) General Electric Company, Schenectady, N. Y., and F. W. Cramer (M '40) Carnegie-Illinois Steel Corporation, Pittsburgh, Pa. The second session considered power distribution in the mining and glass industry and met on Thursday, January 29, with R. T. Woodruff (M '43) Aluminum Ore Company, St. Louis, Mo., as chairman.

STEEL MINES AND MILLS

"Short-Circuit Currents in D-C Systems," was the subject of a paper by William Deans (F '30) I-T-E Circuit Breaker Company, Philadelphia, Pa., who said that many large concentrations of d-c power exist where machines—generators and motors—closely are connected on a relatively short bus. A common example is a rolling mill in a steel or similar plant. A short circuit on such a system can cause current of enormous magnitude, especially where the voltage is 600 volts, and this is usual. In the study of these short circuits, it is necessary to know not only the final or Ohm's law value of the current, but also to know the manner in which the current arrives at the final value, that is, the curve of current versus time.

To study in accurate detail the circuit including one or more d-c machines is very complicated, involving definite data concerning the particular machines. It is possible, though, to regard the circuit as one of resistance and inductance, and with appropriate values of each, conclusions, while perhaps not precisely correct, are acceptable. General data are available from which the resistance and the inductance to be used in the computations may be calculated. Often, the inductance is obtainable and may not have to be inferred from general data.

The resistance effective for the purpose is the ratio of the operating voltage to the final or Ohm's law value of the short-circuit current. It is not really the resistance of the machine. The final value of the current is obtained from the rated full load value by the short-circuit ratio (k) of the machine.

$$I_{\text{final}} = kI_{\text{full load}} \tag{1}$$

The inductance may be obtainable from the machine manufacturer, may be approximated by computation using certain machine design data, or may be estimated from general performance data. In the last case, the initial rate of rise of short-circuit current may be judged from general machine characteristics and from it, the inductance is computed. The equation for a resistance plus inductance circuit is

$$i = \frac{E}{R}\left(1 - \epsilon^{-\frac{R}{L}t}\right)$$
$$= I_{\text{final}}\left(1 - \epsilon^{-\frac{R}{L}t}\right) \tag{2}$$

Evaluating the differential with respect to time of Equation 2 for $t=0$,

$$\left.\frac{di}{dt}\right]_{t=0} = \frac{E}{L} \tag{3}$$

Assuming $\left.\frac{di}{dt}\right]_{t=0}$ to be known, the inductance L may be computed, using equation 3.

Knowing L and the effective value of resistance, equation 2 then may be used to plot the current-versus-time curve. Instants of interest are chosen, those values are assigned to t, and corresponding values of i are determined. Curves so computed have been found to check fairly well with oscillograms of short-circuit currents.

"Features of a New A-C Bus Design" (48-16), were reported by Robert N. Wagner (A '44) of the Aluminum Company of America, Pittsburgh, Pa. To improve the reactance of the bus assembly by enabling closer spacing of the conductors, each phase bus is a modified-U channel with the sides at 150-degree angles to the base. Center of the assembly is a phenolic resin insulator to which the three phase channels are attached by heat-treated aluminum alloy bolts. A lightweight aluminum housing surrounds the assembly and is supported from the bus at 10-foot intervals with simple cylindrical phenolic resin insulators. Simplicity and ease of installation and of making future taps compare favorably with other bus assemblies as does weight per foot and safety to personnel.

The variations of fault currents caused by arc drop compared with fault currents predicted on the basis of a "bolted" fault, has been the subject of extensive tests and were described in "Arcing Faults Current in Low-Voltage A-C Circuits" (48-26), by C. F. Wagner (F '40) and L. L. Fountain (M '45), of the Westinghouse Electric Corporation, East Pittsburgh, Pa. Though the drop across an arc is quite variable, it is an appreciable fraction of the circuit voltage and therefore is reflected in the magnitude of the current. It was found that on 250- and 125-volt a-c circuits, arcing faults are unstable and will extinguish themselves within two cycles or less (with 4-inch bus spacing). The 500-volt faults were also unstable and extinguished themselves in about half of the tests. Curves of arc drop versus average current and line voltage were plotted and indicated that the sustained current may be less than 0.810 of the bolted symmetrical current.

MINING AND GLASS INDUSTRY

In his presentation of his conference paper on "Power for Plate Glass," James E. Arberry, Pittsburgh Plate Glass Company, Pittsburgh, Pa., noted the fact that the only other publication on this subject was written about 23 years ago, and since that time the industry has changed to continuous process methods of manufacturing. After a short discussion of the high load factor of the modern plate glass plant, Mr. Arberry continued with a brief description of the continuous manufacturing process and from that point proceeded to outline the load additions that have occurred in the past decade, largely as a result of the development of glass fabricating techniques, and he supplied figures to show that the load additions necessitate a review of the original power system. As an example he took the Ford City plant of the Pittsburgh Plate Glass Company and described the original power system with the changes and additions that have been made in the past 20 years, the addition being largely the installation of a 13.2-kv transmission system superimposed over a 575-volt system. He mentioned the fact that the new unit substations connected to the 13.2-kv system have been installed with grounded neutral transformers on the low-voltage side. In other words, the company now is operating these units with a 575-volt grounded neutral system.

Because of the disastrous fires in coal mines resulting from fallen trolley wires and feeder cables, a committee and six subcommittees were formed to study the problem. Pending publication of the full report of all six subcommittees, the sectionalization subcommittee reports compiled by representatives of operators, manufacturers, and the Bureau of Mines and State Inspection Department, were presented in the paper, "The New D-C Sectionalization Application Standards" (ACO 48-65), by M. W. Pennybacker (M '44) and Donald J. Baker, of the I-T-E Circuit Breaker Company, Philadelphia, Pa. Application of the standards probably will be enforced just as rapidly as understanding of the old hazards can be brought to the attention of those responsible for their correction. Although primarily adopted because of the safety requirements, the new standards undoubtedly will effect distribution economies. Complete freedom as to kind of overcurrent protection in each application is allowed. The standards themselves consist of 11 points, based upon recognized good practice, which should govern the placement of overcurrent protective devices in and between substations and on equipment.

ELECTRICITY AIDS ANTHRACITE PRODUCTION

Strip mines, an increasingly important factor in the production of coal, may vary considerably in both size and life. Although Diesel and gasoline power is used in some operations, the larger longer-lived mines use electrically driven equipment. Distribution problems peculiar to these applications were discussed by Albert Brown (A '45) of The Philadelphia and Reading Coal and Iron Company, Pottsville, Pa., in his presentation of "Power Supply for Strip Mining." The average stripping load today consists of shovels, drill rigs, machine shops, welders, compressors, and cleaner plants. Connected loads may range up to 3,800 horsepower and can produce quite large momentary demands. Nevertheless, the diversity factor lowers the 15-minute integrated demand. Primary power factors may be as high as 0.98 if leading power factor motor generator sets are used on the drag lines. Transformer substations vary in type and size with the connected load and the probable life of the project. One kilovolt-ampere capacity for each horsepower of connected load is good practice. Unit-type substations are being used for large installations. Service to the strip mines may be 2,400-volt 3-wire or 4,160-volt 4-wire, the latter being preferred for large equipment. Although many mines use the circuit breaker at the transformer station to clear any line or cable fault, portable switch houses now are being used to localize trouble and eliminate delays. Portable cables connect stripping equipment to the overhead lines. Splices usually are made in junction boxes. Cable faults may be corrected temporarily by taping; vulcanizing and other permanent repair equipment now is being included in many layouts. The frequently necessary handling of live cables is done with rubber gloves and hook sticks.

STEEL MILL POWER SYSTEMS

The conference paper "Basic Patterns for Arrangement of Electric Power Systems for Steel Mills," by H. J. Finison (A '43) General Electric Company, Schenectady, N. Y., included a general description of the steel mill power systems and problems. Possible arrangements for the power system to meet steel mill problems were described. The use of aerial cable and indoor metal-enclosed switchgear was suggested to reduce the problems of insulator cleaning. System capacity up to about 30,000 kw can be interconnected directly without use of reactors and still not exceed short-circuit current beyond the rating of 500-megavolt-ampere switchgear. For larger systems, circuit breakers of higher interrupting capacity and reactors must be used. It will be desired to limit the short-circuit current to the ability of 500-megavolt-ampere circuit breakers at the load on subdistribution busses. A system arrangement with a synchronizing bus has considerable advantage. In this arrangement power supply capacity is matched with load supplied from a generator bus which is capable of independent operation. Yet, the bus simply is tied to the main power system through reactors to a synchronizing bus. Where all of the generating capacity is supplying load in an area close to the power station, system voltage usually will be 6,900 or 13,800, with the former giving lower cost for the large motors and the latter giving lower cost for switchgear and distribution lines as a result of the lower current. An economic study of the individual plant is required to determine which voltage should be adopted. Where it is necessary to interconnect two powerhouses which are located some distance apart, or where supply capacity is located remote from the generating station house (location is determined by availability of waste gas, fuel), a higher voltage than 13,800 may be required. In this instance, those generators matched by local loads have their generator bus connected to a high-voltage bus through transformers. Those generators not matched by local loads are connected directly to the high-voltage bus through transformers without switchgear on the generator side. Where higher voltage is required, 33 kv has advantage over 22 kv by giving lower cost transmission lines. Yet, switchgear and transformer costs are substantially the same as for 22 kv. Indoor station-type switchgear in steel cubicles can be used at 33 kv. A voltage of 69 kv may give lower transmission line cost provided large amounts of power are to be transferred but use of outdoor stations is required. While the principles outlined in the paper are directly applicable to new systems, they present convenient methods of expanding an existing power system.

Improvement of Performance Discussed at Session on Distribution Circuits

A conference on distribution circuit protection, construction, service continuity, and fault records was held Wednesday afternoon during the AIEE winter meeting in Pittsburgh, Pa. The primary purpose of the conference was to discuss how to improve the performance of distribution circuits so as to reduce service outages resulting from faults in this part of electric distribution systems. The subject is considered important because outages are becoming more seriously inconvenient as electric service is being used more extensively, and in all but the most densely populated areas the distribution circuit is the most frequent offender in causing service interruptions of long duration. The session was presided over by H. Cole (M '27) Detroit Edison Company, Detroit, Mich.

SECTIONALIZING DEVICES

"Selecting Distribution Line Sectionalizing Devices," by R. F. Quinn (M '44) General Electric Company, Schenectady, N. Y., discussed the problems of minimizing the effects of faults that occur on overhead primary distribution lines. Faults are classified as being "persistent" and "nonpersistent." The effects of faults may be minimized by eliminating prolonged outages caused by nonpersistent faults, and by limiting the extent of outages (that is the number of consumers affected) and the duration of interruption caused by persistent faults. For intelligent sectionalizing practice, consideration should be given to such factors as importance of service, total number of faults per year, ratio of nonpersistent to total faults, cost of service trips, and annual charge on investment. The best protection from the standpoint of achieving minimum consumer hours outage on a feeder having both types of faults is to provide an automatic reclosing circuit breaker at the feeder source; and supplement this with one or more oil circuit reclosers, provided the station circuit breaker will not cover the entire system. All branch taps one-half mile or more in length must be protected with single-shot cutouts. The station circuit breaker relaying or oil circuit recloser characteristic must be such as to protect sectionalizing and branch fuses on nonpersistent faults, but to permit these fuses to clear in event of persistent faults. Such a system provides virtual freedom from outages in the event of nonpersistent faults, and also provides satisfactory isolation of persistent faults, which means that this system will provide a minimum of consumer minutes outage and operating expense. A disadvantage

of this type of system is that the circuit breaker must trip for every fault within its orbit and thus cause momentary outages of one-half to one second or so to all consumers on the feeder, to protect service to all the branch taps on the circuit. If this type of circuit breaker relaying is not to be used, then the next best system to be used is a reclosing circuit breaker at the station, with time delay tripping only plus sectionalizing and branch circuit fuses—used in a way to produce lowest possible consumer-minutes-outage with such a circuit. If the station circuit breaker will not reach to the end of the feeder, then one or more oil circuit reclosers must be used to provide automatic reclosing over the remainder of the feeder. Branch circuit feeders are to be used in such a way as to produce the lowest possible consumer-minutes-outage (*CMO*). Each branch tap should be tested to determine, if by fusing it, there will be a gain or loss in *CMO*. A simple formula is used to determine the effects of branch circuit fusing on continuity of service. The method consists of comparing *abc* which is the *CMO* caused on a given branch by fusing it, with *ABC* or the *CMO* caused to the remainder of the feeder by not fusing the given branch.

a—the number of temporary faults on the given branch

b—the time required to replace fuse in the given branch

c—the number of consumers on the given branch

A—the number of permanent faults on the given branch

B—the time required to determine that the given branch is faulted and to isolate it

C—the number of consumers on the feeder (less the given branch)

Thus, if the product *abc* equals the product *ABC*, then the total *CMO* for the feeder will be the same whether or not the given branch is fused. If *abc* is greater than *ABC*, then the given branch should not be fused because then the total *CMO* will be increased. Finally, if *abc* is less than *ABC*, then the given branch should be fused because then the total *CMO* will be decreased. An example illustrating the use of the "*abc*" method was presented. An extension of the method is used to determine whether single-shot cutouts should be used. Consideration also must be given to the relative cost of 2-shot and 3-shot cutouts, as well as the relative benefits each one provides. It was pointed out that in many instances the ratio of faults on any one feeder, let alone any one branch, is not known, and that the time required to locate a fault or replace a fuse depends upon too many circumstances and is too indeterminate. These factors were recognized and it is therefore necessary to work on averages. In general, operating companies assume a ratio of faults that is average for their system. They also have assumed an average length of time required to replace a blown fuse in an average figure for a given area to restore service in the event of a persistent fault. It is also common to use "kilovolt-ampere of load" affected by outage, rather than "number of consumers." Using these assumptions, it is logical to arrive at a certain size of branch, in terms of connected load, which is the dividing line between fusing and not fusing.

REPEATER FUSE SECTIONALIZING

The second paper in this conference session was "Nine Year Operating Record of Rural Line Sectionalizing by Repeater Fuses," by R. M. Schahfer (A '44) Northern Indiana Public Service Company, Hammond, Ind. It was pointed out in this paper that the Northern Indiana Public Service Company has had excellent results in the application of repeater fuses to sectionalizing of rural lines. They have depended on repeater fuses and have practically no reclosing oil circuit breakers other than those in the substations. This successful operation has been the result of considerable care in:

1. Recommending the proper size of fuse link to be used at each location.
2. Choosing the locations.
3. Seeing that men in the field are instructed as to the size of the fuse to be installed.
4. Choosing a fuse link which has been found satisfactory and using only this one type of link, thus avoiding any differences in the blowing or melting characteristics of the fuse links of different manufacturers.

In assigning locations and sizes of sectionalizing fuses consideration is given to loading on the line, location of hazards, and grouping of customers. In general, it usually is desirable to fuse the branches of a circuit and frequently, a number of subbranches. A fuse location is determined not so much from the importance of the line it will disconnect, as from the potential damage that the line can cause the balance of the system. Co-ordinating fuses with oil circuit breakers is made quite simple by equipping the circuit breakers with overcurrent relays having extremely inverse time characteristics, which, in effect, makes the tripping time of the circuit breaker similar to fuse blowing time. In assigning fuse link sizes, perfect co-ordination is desired. By perfect co-ordination is meant that a solid short circuit shall blow all three shots of a repeater and at the same time shall not blow even one fuse on the repeater nearer the source of power. This tends to place a limit on the number of permissible sectionalizing points in series. Occasionally the number of fuses desired in series on a given circuit makes it impossible to obtain perfect co-ordination, and so in a few instances the advantage of an extra sectionalizing location is enough to justify imperfect co-ordination. In such instances, an attempt is made not to exceed that condition wherein more than one fuse will be blown while three fuses in the repeater beyond it are blowing. Such imperfect co-ordination is not as serious with repeater fuses as it would be with single shot fuses. A strict inspection or patrolling schedule is not maintained by the company. They have depended on the belief that most cases of trouble which are permanent will blow all three fuses and must be located and remedied; and that other faults rarely blow all three fuses. Thus the third reclosures protect the service until the blown fuse is discovered and replaced. Maintenance personnel are instructed to observe the various fuse locations while on routine work. Blown fuses either are replaced or arrangements are made for the replacement, and if possible a patrol to locate blown fuses is made after each major storm. The foregoing procedure is sufficient and additional routine inspections or patrols are not warranted is the belief of the company. A 9-year analysis of the results obtained by using repeater fuses in only one district were presented in a series of 14 tables. The analysis prompted the following conclusions:

The use of 3-shot repeaters are warranted over the cost of 2-shot repeaters on the basis of cost per case of trouble restored, because of better service to customers by more successful reclosures, and because expensive routine patrols are less necessary.

In addition to usual economies, there is an additional value in service-restoring devices because they lessen the demand for workmen during the peak trouble time, and automatically restrict the faulted line to a small area.

Repeater fuses should be inspected when refused to be sure that no burr or badly burned spot has been created which will prevent future correct operation. Repeater fuses are of little value in restoring service during sleet and ice conditions but they will sectionalize the line trouble.

The repeater fuse clearly shows a lockout to the patrolman and thus aids in speeding line patrolling.

The company was reported to be well pleased with repeater performance and plans to extend their use.

THIRTY YEARS OF RELAY PROTECTION

The final paper in this session was "Thirty Years' Experience in Relay Protection of Distribution Feeders," by C. L. Headley (A '42) Consolidated Gas, Electric Light and Power Company of Baltimore, Baltimore, Md. This paper summarized the various changes in relay protection for the distribution feeders of the Consolidated Gas, Electric Light and Power Company of Baltimore from 1914 to 1947. Quick acting plunger-type overcurrent relays originally were used for tripping the circuit breakers in the distribution feeders. The relays were adjusted to operate and immediately trip the circuit breaker on faults at any location on the feeder. As early as 1914, the observation, that very often when a circuit breaker tripped because of fault current the fault was cleared and service restored when the circuit breaker was closed, gave rise to the idea of reclosing the circuit breaker automatically to restore service more quickly. The first method of automatic reclosing was designed in 1914 and was arranged to effect immediate reclosures following the first two consecutive tripouts and lockout on the third tripout. It was designed for use only on circuits equipped with instantaneous-overcurrent tripping relays and was installed on the majority of their 4,150-volt distribution feeders. This method of relaying rendered satisfactory protection for many years, and records on the operation of this method

of relaying show that service was restored promptly approximately 75 per cent of the times the circuit breaker tripped because of fault current. By 1930 the company's system had grown considerably. The distribution feeder loads had increased, higher rated fuses had been installed in the taps, and the feeders had become more complicated by the increased number of fused taps. It then became apparent that the original method of relay protection was not wholly adequate. A revised method of relaying that facilitated co-ordination between the station circuit breaker and the feeder fuses and which provided for picking up cold loads when energizing the feeder was installed. Inverse time overcurrent relays equipped with instantaneous tripping attachments were used. These relays were adjusted to co-ordinate with the feeder fuses; the instantaneous trip attachments were set to operate only on high values of current for quickly clearing faults near the station bus. These relays operated on phase overcurrent and were used successfully for a number of years. This new type of relaying made it necessary to change the type of automatic reclosing. The new scheme provided for one reclosure after the first tripout followed by lockout if the second tripout occurs within a predetermined time (approximately 30 seconds). By 1943, the majority of the 4,150-volt feeders were equipped with this type of relaying. Records taken over a period of years showed the following results:

1. The number of tripouts had been reduced considerably.

2. The number of fuses blown had been increased.

3. The number of service restorations by automatic reclosing was approximately 55 per cent. (This loss of 20 per cent is caused primarily by the longer fault clearing times, resulting from the use of inverse time relays.)

4. No difficulty with relay operation had been experienced from inrush current when energizing a feeder, if the normal load on the feeder was not more than 75 per cent of the relay setting.

Although using this method of relaying gave a high degree of service protection and a good percentage of service restoration, some faults resulted in permanent troubles because they were not cleared quickly enough. It also was believed that many fuses were blown by faults of a temporary nature. If such faults could be cleared by tripping the feeder circuit breaker before the fuse operates, the service would be restored immediately by automatic reclosing and customers would experience only a momentary outage. About 1935 a relaying method using this idea was developed and has resulted in improvement to the service. This method is designed to trip the circuit breaker by high-speed relays on the majority of initial faults on the feeder. The circuit breaker then is reclosed automatically. If the fault is not cleared when the circuit breaker is closed, the second tripout is initiated by inverse time relays. When the second tripout occurs, the fault is considered permanent and no further automatic reclosure is initiated. The high-speed tripping on the initial fault provides quick clearing to minimize the amount of damage that might be caused by the fault and generally prevents the unnecessary blowing of fuses located between the circuit breaker and the point of fault. The time delay tripping on the second immediate tripout, provides co-ordination between the station circuit breaker and the feeder fuses. This method of quick trip on the initial fault and time delay for the second immediate tripout was tested during 1936 and 1937 by applying it to one of the 4,150-volt distribution feeders. Later in 1938, the length of this feeder was reduced for reasons other than the test to approximately 31 miles, and no other changes were made to the feeder. Because of changes in station control however, the relays that have been installed for test were replaced by inverse-time overcurrent relays only. The following is the operating record of this feeder when it was equipped with the special relaying installed for a test, as compared with the record when the feeder was equipped only with the inverse time relays and automatic reclosing:

1. With both methods of relaying, approximately the same number of faults were experienced per year per 100 miles of feeder.

2. With the first method approximately 62 per cent of the times when the oil circuit breaker tripped and reclosed, the fault was cleared and the circuit breaker remained closed as compared with 41 per cent for the second method.

3. With the first, approximately 53 per cent of the times when the circuit breaker tripped and reclosed, the fault was cleared and no load was lost as compared with 35 per cent for the second method.

4. With the first, approximately 34 per cent of all faults on the feeder were cleared by opening and closing the circuit breaker without loss of load as compared with approximately 18 per cent for the second method.

During 1947 the company installed metal-clad switchgear on all the 4,150-volt feeders in two of their major 4-kv substations. The switchgear is equipped with instantaneous relays to initiate quick tripping on the initial fault, automatic reclosing, and inverse-time relays to initiate the second immediate tripout. Ground relays, in addition to phase relays, are used on this equipment and they provide quick tripping on the initial ground fault and inverse time on the second immediate tripout. The company plans to equip the majority of its 4,150-volt feeders with this method of protection.

ARCING FILMS SHOWN

During this session two motion picture films on "Destruction Arcing on Overhead Distribution Wires," were shown. R. M. Smith (M '46) of the Railway Industrial Engineering Company, Greensburg, Pa., supplemented the showing with some explanatory remarks. Some excellent scenes of the destructive effects of arcs occurring on feeder systems (some of these in color) made a very interesting presentation

Communication Components and Techniques Make for Interesting Session

A program accommodating four technical and two conference papers was the feature of an interesting session on communication components and techniques held on Wednesday, January 28. H. I. Romnes (A '41) American Telephone and Telegraph Company, New York, N. Y., presided.

RECENT IMPROVEMENTS

The first part of the session was devoted to developments in the telephone and telegraph industry, the first paper being "Recent Improvements in Loading Apparatus for Telephone Cables" (48-59), by S. G. Hale (M '46), A. L. Quinlan (M '45), and J. E. Ranges. Mr. Quinlan is with the Western Electric Co., Chicago, Ill., and the other two authors are with the Bell Telephone Laboratories, New York, N. Y. A new insulating enamel for copper wire has enabled the elimination of supplementary textile insulation formerly required over the enamel. A new single-ring winding machine has made it commercially possible to wind toroidal coil to inside diameters as small as 0.35 inch. Thus savings in copper, volume, and weight are possible without reduction of quality in exchange area loading coils, and 3-unit toll cable loading units.

SIGNAL ANALYZER

"A Telegraph Signal Analyzer" (48-60), was described by G. L. Erickson (M '44) of The Western Union Telegraph Company, New York, N. Y. Personnel can be trained quickly to identify transmission and equipment troubles from inspection of the circular paper charts produced by either transmission of test signals or actual commercial transmission. Basically, the mechanism consists of a synchronous motor geared to drive a shaft at 420 rpm and a selector magnet assembly which operates a stop latch, thereby starting the recording disk at the correct point in a train of pulses. The first, or start pulse, of a 7-unit or similar 7.4-unit code serves to "trigger" the rotation of the disk. During the next five 0.022-second pulses each mark-to-space and space-to-mark transition is recorded by a short line made by a stylus on the rotating disk. During the seventh, or stop pulse, the disk finishes one rotation and awaits the next start pulse. Under perfect operating conditions each of the recorded transition marks will fall along radio lines printed on the chart. Several types of distortions were illustrated and the resulting chart explained. Each type of signal distortion gives a characteristic displacement of the chart markings.

LOCATING SYSTEM

The need for locating torpedoes lost on their test runs prompted the development of underwater supersonic transmission and receiving equipment. In presenting "An Electroacoustical Locating System" (48-8), Eric A. Walker (M '41) head of the department of electrical engineering at The Pennsylvania State College, State College, Pa., explained that this is one of many recently developed applications for sound waves. Operating at 25 kc per second (selected as a compromise between attenuation of the wave and necessary size of the equipment), a magnetostriction projector transmits sound waves to the water surrounding the lost torpedo by means of a rubber diaphragm. Search boats are equipped with hydrophones which consist of one or more nickel tubes surrounded by an electric winding in which the signal is reproduced. A lucite streamlined housing matches the acoustical impedance of the water. Directivity of projector and receiver is used to determine the exact location of the missing projectal. A diver, using a chest hydrophone if necessary, then may recover the torpedo. Demodulation of the received signal is achieved by conventional beat-frequency techniques.

DIRECTOR SYSTEM

"The Director for Automatic Telephone Switching Systems" (48-99), was described by Arthur Bessey Smith (F '22) of the Associated Electric Laboratories, Chicago, Ill. Although first installed in Havana, Cuba, in 1924, the director system has not come into wide usage in the United States. If used with tandem trunking, it makes possible a universal numbering system (one in which the dialed number is the same irrespective of the location of the two telephones involved). By storing the digits as they are dialed and transforming the office code into a directive, it is possible to route calls to the right exchange office in a tandem system without an operator. The development, performance, and basic principles of this system were discussed.

ROTARY SWITCHING SYSTEM

R. W. Engsberg of the Federal Telephone and Radio Corporation discussed "Rotary Switching for Small Community Telephone Exchanges." The Rotary switching system for small community exchanges has in it several new and novel features not contained in other systems. One of these, and perhaps the most novel, is the use of a register. This permits the segregation of toll and local traffic to allow the completion of incoming and outgoing toll calls although all local links may be occupied. All impulses received from the line are received by one relay which is designed to receive and record pulses under the most severe line conditions; this insures uniform operation of the system regardless of ringing line conditions. The operation of the switches in the system are independent of line conditions as they are driven by a constant speed motor which causes them to operate at constant speed and therefore send constant revertive pulses back to the register to satisfy the condition established by the line dial pulses.

The concluding paper was presented by R. F. Dirkes, of The Western Union Telegraph Company, New York, N. Y., and was entitled "Modern Reperforator Switching System for Patron Telegraph Service."

All-aluminum frame construction reduces weight, thereby reducing cost of building construction and handling costs. Completely wired and cabled package-type circuit units can be stocked by the telephone company and added to the unit as traffic conditions require them. These circuit units are mounted on standard aluminum mounting plates which mount on aluminum gates with a capacity of five mounting plates each. The cable is attached to the circuit plates in the factory and is connected directly to easily accessible switch arcs or to other circuits as required. All terminal blocks thus are eliminated and the number of connections required to be made by the installer is reduced to a minimum.

The use of one type of switch, the 100-point rotary selector, simplifies maintenance and stocking of repair parts. This switch is a simple gear-driven brush assembly of simple yet rugged design which has withstood 5,000,000 operations without failure or appreciable wear. This is equivalent to more than 35 years service in an exchange with greater than normal traffic. When a subscriber calls another subscriber who is on the same party line, revertive call, he dials the directory number tones, receives a signal that advises him he has made a revertive call. He thereupon hangs up his receiver and immediately the bell of the subscriber he called beings to ring. When the called subscriber answers he receives a signal (tone) that tells him he is receiving a call from another subscriber on his line indicating that he should wait for the calling subscriber to pick up his receiver. When the called party answers, all switches are released and only the line relay is engaged.

Meeting Program Includes Basic Sciences Session

Basic sciences was the subject for discussion at an afternoon session on Wednesday of the winter general meeting. Chairman was J. D. Tebo (M '36) Bell Telephone Laboratories, Inc., New York, N. Y.

The first paper of the session, "A Critical Analysis of Voltage Conventions, and Double-Subscript Notations" (48-1), by Myril B. Reed (M '43) and W. A. Lewis (F '45) of the Institute of Technology, Chicago, Ill., points out that great confusion exists in electrical engineering literature because of the lack of uniformity in designating voltages and potential differences. A possible set of standards is offered.

. Considerable interest was shown in this paper which was presented by Doctor Lewis, and was followed by six prepared discussions. In fact, it was necessary for lack of time, to close the discussion at this time, although others were desirous of presenting their views. It is suggested that letters be sent to the editor of *ELECTRICAL ENGINEERING* on this subject to complete the discussion, as the paper has been published (*EE, Jan '48, pp 41–8*).

"Hystero-Viscosity in Silicone" (48-58), by Michel G. Malti (M '45) of Cornell University, Ithaca, N. Y., and A. K. Chatterjee (Student Member) of the University of Illinois, Urbana, Ill., presented curves and equations describing the hystero-viscosity loss (exhibited in lapse of time during charging and decrease in voltage during discharging which is thought to result from internal adjustments within the dielectric) of solidified silicone resins. Period of charge or discharge, interval between successive charges and discharges, and maximum applied voltage are parameters of the equation. Comparison of computed data and test results is remarkably close.

ATTENUATORS AND TERMINATIONS

"Attenuator Materials, Attenuators, and Terminations for Microwaves" (48-68), by

The 66-kv 10,000-kva series capacitor installation, inspected on Thursday

G. K. Teal, M. D. Rigterink, and C. J. Prosch, of the Bell Telephone Laboratories, Murray Hill, N. J., described the wartime research on high-power microwave attenuators and terminations. High attenuation, negligible reflection, chemical stability, thermal conductivity and stability, ease of reproduction, and compactness are prime factors in the choice of attenuator shape and material. The particular requirements of the job govern the type of material to be recommended, but dispersions of conducting or semiconducting particles in low loss solid dielectrics offer many advantages. Ceramics, plastics, and rubber-bonded materials each have advantages in specific applications. Choice of a shape for an attenuator pad is governed primarily by space requirements, production requirements, and the necessity for eliminating standing waves resulting from reflection. Characteristics of various materials and designs were given as well as a demonstration of microwave attenuators.

INSULATION BREAKDOWN

The use of statistical methods for determination of "Insulation Breakdown as a Function of Area" (48-69), was given by L. R. Hill (M '46) and P. L. Schmidt (A '47) of the Westinghouse Electric Corporation, East Pittsburgh, Pa. Experience has shown that the probability of failure at a low voltage increases as the area of insulation under test is increased. This has been recognized in practice by applying empirical factors of safety to adjust test data to the larger insulation areas used in the field. Straightforward application of the law of probability can be used to give equations for the breakdown of n elementary areas in parallel as related to the probability of breakdown for one elemental area. Application of this analysis will enable predictions concerning insulation performance to be made when the relative areas are known.

MATHIEU EQUATION

Network theory for linear circuits having varying parameters has not been developed as completely as for constant-parameter networks. However, in specific applications, there is great need for published tabular solutions of certain equations. Hence, Harry J. Gray, Richard Merwin (46), and J. G. Brainerd (F '47), of the University of Pennsylvania, Philadelphia, Pa., have submitted "Solutions of the Mathieu Equation" (48-70). The solution of the Mathieu equation, $(d^2y/dt^2)+\epsilon(1+k \cos t)y=0$, was presented, as well as 12 pages of tabular numerical solutions.

PERSONAL • • • •

L. B. Chubbuck (A '18, F '43) consulting engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ontario, Canada, has retired after 47 years of service with that organization. Born in Ottawa, Ontario, Canada, on November 30, 1877, Mr. Chubbuck was graduated from the University of Toronto in 1900 with a bachelor of science degree in electrical engineering. He entered the employ of the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation), East Pittsburgh, Pa., in 1900. In 1909 Mr. Chubbuck transferred to the Canadian office in Hamilton where his work was concerned mainly with the design of switching equipment. He was appointed assistant chief engineer for that company in 1936 and was promoted in 1946 to the position which he held at the time of his retirement. Mr. Chubbuck is, a past chairman of the Toronto Section of the AIEE and a past vice-president of the Canada District (10) of the AIEE. He served on the AIEE protective devices committee for the years 1922–25, and on the safety codes committee for the years 1931–33.

W. E. Row (A '39) manager of operation, Southern California Edison Company, Los Angeles, has retired. Mr. Row was born on September 1, 1887, in Clearfield, Pa. He first became associated with the Southern California Edison Company in 1908 when he was engaged in substation construction. In 1909 Mr. Row was promoted to the position of meter testman and in 1913 he was placed in the distribution department as an engineer. He left that organization in 1915 to accept a position with the Fobes Company, Ltd., Shanghai, China. In 1923 Mr. Row was employed as an assistant engineer for the California Railroad Commission, but he left that position in 1926 to return to the Southern California Edison Company as an engineer in the distribution department. He was promoted successively to distribution engineer, assistant superintendent of distribution, electrical engineer, and assistant manager of operation for that company, and in 1945 was named to the position which he held at the time of his retirement.

F. P. Lawrence (A '25) vice-president, American Telephone and Telegraph Company, New York, N. Y., retired recently after 35 years of service with the Bell Telephone System. Born on October 18, 1886, in Newark, N. J., Mr. Lawrence was graduated from Lehigh University in 1910. He was engaged in building construction work from 1910 until 1912 when he was employed as an engineer by the Southwestern Bell Telephone Company, St. Louis, Mo. Mr. Lawrence subsequently was advanced to the position of plant superintendent in the St. Louis office and then served in Kansas and Oklahoma companies of the Bell System. In 1929 he was named general plant manager for the upstate area of the New York Telephone Company, with headquarters in Albany. Mr. Lawrence was made vice-president and general manager of that area in 1934 and in 1938 was named to the corresponding position in the Manhattan area. In 1941 he assumed the duties of the position which he held at the time of his retirement.

W. G. Kelley (A '08, F '26) assistant chief electrical engineer, Commonwealth Edison Company, Chicago, Ill., has retired after more than 46 years of service with that organization. Born on February 8, 1879, at Burlington, Iowa, Mr. Kelley was graduated from the Massachusetts Institute of Technology in 1901 with a bachelor of science degree in electrical engineering. He became associated with the Commonwealth Edison Company in that same year as an inspector of electrical wiring for customers in the western district of Chicago. Mr. Kelley was promoted successively to assistant district engineer, overhead engineer, assistant engineer of distribution, and plant design engineer. He was named assistant chief electrical engineer in 1943. He is a member of the American Society for Testing Materials, the National Electric Light Association, the American Standards Association, the International Electrotechnical Commission, and the International Conference on Large Electric High Tension Systems. At the time of his retirement he was vice-chairman of the Utilities Research Commission. Mr. Kelley served on the AIEE power transmission and distribution committee for 1924–25.

T. G. LeClair (A '24, F '40) former chief staff engineer, Commonwealth Edison Company, Chicago, Ill., has been named assistant chief electrical engineer for that company. Mr. LeClair is an electrical engineering graduate of the University of Idaho. He became associated with the Commonwealth Edison Company in 1923 and was appointed in 1945 to the position which he held previous to his promotion. Mr. LeClair is secretary of the postwar and plan subcommittee of the Edison group of companies, chairman of the Inter-Company Engineering Conference, and chairman of the Washington Award Committee. He is a vice-president of the AIEE for District 5 and is chairman of the professional group co-ordinating committee.

F. W. Knoeppel (M '44) formerly an electrical engineer, Miami, Fla., now is sales representative in the state of Florida for the Walker Electrical Company of Atlanta, Ga., the Electrical Engineers Equipment Company of Melrose Park, Ill., the Standard Transformer Company of Warren, Ohio, and the Major Equipment Company of Chicago, Ill.

F. T. Hawke (A '46) formerly process engineering supervisor, Seeger Refrigerator Company, Evansville, Ind., has accepted a position with the International Harvester Refrigeration Division, Evansville, Ind.

C. C. Hill (M '47) formerly associated with the American Enka Corporation, Enka, N. C., has been appointed plant electrical engineer for the new plant of that corporation which has been established at Lowland, Tenn.

R. W. Adams

M. M. Koch

P. H. Maurer

R. W. Adams (A '06, F '44) assistant district manager, apparatus department, General Electric Company, Boston Mass., retired recently after more than 40 years of service with that concern. Born in Royalston, Mass., on October 27, 1881, Mr. Adams was graduated from the Worcester Polytechnic Institute in 1904 with a bachelor of science degree. He also received an electrical engineering degree from that institution in 1908 for research work in connection with the design of enclosed fuses. From 1904 to 1905 Mr. Adams was employed in the machine shop and testing department of the B. F. Sturtevant Company, Hyde Park, Mass., and from 1905 to 1908 he held a position as electrical engineer with the D & W Fuse Company, Providence, R. I. Mr. Adams became affiliated with the Pittsfield, Mass., office of the General Electric Company in 1908 and after serving in the transformer department for two years he was transferred to the Boston, Mass., office as a transformer specialist. He later was advanced to the position of sales engineer, and in 1913 was made manager of the Providence office. Mr. Adams was promoted to district central station department manager in 1928 and in 1942 to the postion which he held at the time of his retirement. Mr. Adams is a member of the American Association for the Advancement of Science, the National Society of Professional Engineers, the American Management Association, Phi Sigma Kappa, Tau Beta Pi, and of Sigma Xi. He served on the AIEE education committee for the 1931–32 term, and on the AIEE membership committee from 1933 to 1936. He also served as chairman of the Boston Section of the AIEE for the year 1940–41.

D. R. Shoults (A '35, M '42) chief engineer, the Glenn L. Martin Company, Baltimore, Md., has been named vice-president in charge of engineering for that company. He will handle the duties of both positions until a successor as chief engineer is named. Mr. Shoults is a 1925 graduate of the University of Idaho from which he received a bachelor of science degree in electrical engineering. He has been affiliated with the Glenn L. Martin Company since 1947 when he accepted the position which he held prior to his recent appointment. Mr. Shoults was chairman of the AIEE air transportation committee for 1944–45 and in 1940 was awarded the AIEE national best paper prize in the field of engineering practice.

M. M. Koch (A '20, M '26) formerly assistant general superintendent of electric operations, Public Service Company of Colorado, Denver, has been promoted to the position of vice-president and general superintendent of electric operations for that organization. Mr. Koch was graduated from Cornell University in 1913 with a bachelor's degree and in 1914 with a master's degree in mechanical engineering. He has been associated with the Public Service Company or related companies since 1914.

C. W. Baker (M '34) formerly chief engineer, the English Electric Company of Canada Ltd., St. Catharines, Ontario, has been appointed engineering consultant to the vice-president of that concern. Mr. Baker is a graduate of Queen's University. **M. B. Mallett** (M '37) formerly transformer engineer with the English Electric Company, will succeed Mr. Baker as chief engineer. Mr. Mallett is a graduate of Rensselaer Polytechnic Institute.

P. H. Maurer (A '33) formerly chief engineer, the National Pneumatic Company, Rahway, N. J., has left that organization to accept the newly created post of director of engineering with the Redmond Company, Inc., Owosso, Mich. In his new capacity Mr. Maurer will be in charge of all engineering work in the concern. He had been associated with the Redmond Company previously as an executive engineer in 1943 but left that position 18 months later to become manager of industrial sales for the National Pneumatic Company.

P. L. Bellaschi (A '29, F '40) formerly section engineer, Westinghouse Electric Corporation, Sharon, Pa., now is engaged in consulting engineering in Sharon. Mr. Bellaschi was graduated from the Massachusetts Institute of Technology with a bachelor of science degree in electrical engineering in 1926 and a master of science degree in 1928. He later received an honorary degree as doctor of science from Washington and Jefferson College. Mr. Bellaschi served as a United States delegate to the International Electrotechnical Commission at the 1937 and 1939 meetings held in Paris, France.

W. L. Cisler (M '35, F '47) formerly chief engineer of power plants, The Detroit (Mich.) Edison Company, has been named executive vice-president under the general manager for that organization. During the war Mr. Cisler served on General Eisenhower's staff in Europe where he directed the re-establishment of utility services. He is a consultant for the United States Atomic Energy Commission.

E. L. Collens, 2d (A '07, M '40) chairman of the board, Reliance Electric and Engineering Company, Cleveland, Ohio, is one of five members of the National Electrical Manufacturers Association awarded gold certificates in recognition of 50 or more years of continuous service to the industry. **J. S. Thompson** (A '14, F '38) president, Pacific Electric Manufacturing Corporation, San Francisco, Calif., also has been awarded a gold certificate in recognition of his service record, as has **A. H. Timmerman** (A '03, F '12) vice-president, Wagner Electric Corporation, St. Louis, Mo.

L. W. Long (A'37, M '44) formerly manager, substation section, electrical department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named general manager of the Boston (Mass.) Works of that company. A 1923 electrical engineering graduate of Pennsylvania State College, Mr. Long in 1925 entered the employ of the Pittsburgh (Pa.) Transformer Company, which two years later was merged with the Allis-Chalmers company. **J. R. Mann** (A '47) formerly application engineer for that concern, has been promoted to the position of engineer-in-charge of transformer sales. Mr. Mann was graduated from Purdue University in 1941 and has been with the Allis-Chalmers company since that time.

Rene Dupuis (M '44) formerly director of the electrical engineering school, Laval University, Quebec, Quebec, Canada, has been appointed superintending engineer of operation, Beauharnois (Quebec, Canada) Light, Heat, and Power Company. Mr. Dupuis received his technical education at McGill University and the University of Nancy, France. **Yvon De Guise** (A '46) formerly assistant to the superintendent, generating stations, Quebec Hydro-Electric Commission, Montreal, Canada, now is associated with the Beauharnois Light, Heat, and Power Company as superintendent of properties and water control.

F. H. Roby (M '41) sales manager, industrial controller division, the Square D Company, Milwaukee, Wis., has been

named assistant general sales manager of the newly organized general sales department for that concern. At present, Mr. Roby will serve the company in both capacities.

O. S. Mitchell (A '23, M '30) formerly commission secretary, executive department, Hydro-Electric Power Commission, Toronto, Ontario, Canada, has accepted the position of secretary for the Brazilian Traction Light and Power Company, Ltd., Toronto. Mr. Mitchell attended Northampton Engineering College, University of London, from 1918 to 1922. He came to Canada in 1923 and for the next four years served on the staff of the commission. After holding several positions with other organizations, Mr. Mitchell was appointed commission secretary in 1938.

N. H. Callard (A '16) formerly a member of the headquarters staff, Westinghouse Electric Corporation, Pittsburgh, Pa., has assumed his new duties in the capacity of manager for the Hilo (Hawaii) Electric Light Company. Mr. Callard had been associated with the Westinghouse Electric Corporation for 35 years. During the war he was loaned to the Navy's Bureau of Ships, Washington, D. C., and later was appointed deputy general representative for the Office of War Information in India.

C. M. Cavner (A '45) formerly assistant manager of operations, the Southern California Edison Company, Los Angeles, has been named acting manager of operations for that company.

C. D. Taylor (M '20) formerly New Orleans (La.) zone manager for the Nash-Kelvinator Sales Corporation, now is serving as Atlanta (Ga.) zone manager for that concern. Mr. Taylor has been with the corporation since 1936.

W. C. Madsen (A '42) formerly application engineer, the Reliance Electric and Engineering Company, Cleveland, Ohio, has been named branch manager of the Gary, Ind., office of that concern. Mr. Madsen was graduated from the Case Institute of Technology in 1941 and has been associated with the Reliance Electric Company since that time.

F. H. E. Myers (M '47) previously on the headquarters staff of the director of the electrical industries branch, Control Commission for Germany, has been appointed technical manager to Export and Technical Services Ltd., London, England. Mr. Myers has been in the testing, plant, and main planning departments of the British Thomson-Houston Company, Ltd., for more than 19 years, and was chief test engineer for the Rugby, Warwickshire, office of that concern for several years before he left the company in 1946.

W. R. Wise (A '44) Water, Light, and Sewer Department, Newberry (S. C.) Commissioners of Public Works, has been elected chairman of the southeastern section of the American Waterworks Association.

C. B. Bradish (M '17) formerly designing engineer, industrial control department, General Electric Company, Schenectady, N. Y., recently was named manager of engineering for that concern. Mr. Bradish was graduated from the University of Wisconsin in 1912 and in that same year joined the General Electric Company.

F. J. Chesterman (A '20, F '22) formerly vice-president in charge of operations, the Bell Telephone Company of Pennsylvania and the Diamond State Company, Philadelphia, Pa., has been elected president of the two companies. Mr. Chesterman has been associated with the Bell system since 1905. He was named vice-president and general manager of the company's western area in 1926 and in 1941 became vice-president of both companies.

H. V. Erben (M '43) formerly assistant general manager, apparatus department, General Electric Company, Schenectady, N. Y., has been elected a vice-president and general manager of the apparatus department of that organization. Mr. Erben was graduated from Yale University, Sheffield scientific school, in 1919. He has been associated with the General Electric Company since 1920.

J. B. Challies (A '43) vice-president and executive engineer, Shawinigan Water and Power Company, Ltd., Montreal, Quebec, Canada, has been made an honorary member of the American Society of Civil Engineers.

K. B. Duerr (M '44) assistant to apparatus engineer, Western Union Telegraph Company, New York, N. Y., is one of ten telegraph engineers who won awards in the Design-For-Progress Award Program of the James F. Lincoln Arc Welding Foundation. Mr. Duerr's winning paper describes a multiplex distributor cabinet which he has designed.

W. S. Gifford (A '16) president, the American Telegraph and Telephone Company, New York, N. Y., is one of the 50 leading businessmen of the nation selected by the vote of thousands of businessmen, according to *Forbes Magazine* (New York, N. Y.). **David Sarnoff** (M '23) president, Radio Corporation of America, New York, N. Y., also was included in that survey's selection.

W. H. Bassett, Jr. (M '30) lieutenant colonel, the United States Army, formerly with the Ordnance Department, Missouri Ordnance Works, Louisiana, is now commanding officer, Ordnance Department, Alabama Ordnance Works, Sylacauge.

W. H. Bollinger (A '44, M '47) formerly in the customer application engineering department, The Esterline-Angus Company, Inc., Indianapolis, Ind., now will represent that concern in the Pittsburgh, Pa., district. Mr. Bollinger is a 1933 graduate of Purdue University.

E. A. Roberts (A '17, M '20) formerly consultant engineer and partner in the firm of Fisk and Roberts, announces the formation of the Roberts Organization, Transit Engineers and Consultants, New York, N. Y. Mr. Roberts will head this new company. **W. H. Ahearn** (A '20, M '23) head of the transit section, Office of Defense Transportation, Interstate Commerce Commission, Washington, D. C., during the war, will serve as engineer on transportation problems for the Roberts Organization.

A. C. Abbott (M '46) formerly electrical engineer, commercial and distribution department, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been named assistant manager of that department of the company. Mr. Abbott has been associated with that organization since 1926.

J. E. Wilson (A '42) formerly superintendent of operation, Colorado Central Power Company, Englewood, is one of the two men appointed vice-president of that company.

T. M. Blakeslee (A '29, M '38) formerly senior electrical engineer, testing laboratories, Water and Power Department, City of Los Angeles, Calif., has been advanced to the position of engineer of transmission and communications, operating division. **Bradley Cozzens** (A '28, M '38) former senior electrical engineer in charge, research and record section, Water and Power Department, has been named executive assistant to the general manager.

W. R. L'Hommedieu (A '42) formerly with the Zinsco Electrical Products Company, Los Angeles, Calif., is now sales representative in the Los Angeles area for the Ward Leonard Electric Company, New York, N. Y.

J. L. Adams (A '42) former senior assistant distribution engineer, Union Electric Company of Missouri, St. Louis, has been promoted to planning engineer for that firm. Mr. Adams has been associated with the Union Electric Company since 1941.

J. E. Jenkins (A '45) engineer, Armature Winding Company, Charlotte, N. C., has been elected president of the southeastern chapter of the National Industrial Service Association.

J. L. Wilcox (A '41) formerly division traffic engineer, Western Union Telegraph Company, New York, N. Y., has been appointed assistant vice-president for that

company. Mr. Wilcox was graduated from the Case Institute of Technology in 1928 and has been associated with the Western Union Company since that time.

C. E. Dreher (A '43) formerly manager of the western hemisphere department, New York, N. Y., office of the Westinghouse Electric International Company, has been appointed sales manager for that organization. Mr. Dreher, a graduate of Brown University, has been associated with the Westinghouse Company for 22 years.

J. P. Maxfield (M '23, F '27) retired member of the acoustic products development group, apparatus development department, Bell Telephone Laboratories, Inc., New York, N. Y., has accepted a position as a consulting engineer with the Altec-Lansing Corporation, Los Angeles, Calif.

F. M. Oglee (A '41) formerly district manager, Trumbull Electric Manufacturing Company, Norwood, Ohio, has been appointed manager of employee relations for the Plainville, Conn., plant of that organization. Mr. Oglee has been associated with the Trumbull firm for 20 years.

W. F. Gray (A '38, M '44) formerly with the electrical engineering department, Massachusetts Institute of Technology, Cambridge, Mass., has become associated with the Toole-Woodward Engineering Company, Charleston, S. C., as field engineer. Mr. Gray is a graduate of the Georgia School of Technology.

Solomon Moldoff (A '47) formerly an electrical engineer with the construction division, New York City (N. Y.) Transit System, is now on the staff of the Moll-Mor Frozen Products Company, New York, N. Y. A graduate of the College of the City of New York school of technology, Mr. Moldoff will be in charge of the service and transportation department of the frozen products company.

B. F. Greene (A '47) electrical and lighting consultant, New York, N. Y., has been appointed technical consultant for the Fluorescent Lighting Association, New York, N. Y. He will serve as consultant to the association and at the same time continue his private consulting practice.

F. K. McCune (A '33, M '43) formerly a member of the apparatus design engineering staff, the General Electric Company, Schenectady, N. Y., has been appointed assistant to the general manager of the apparatus department of that concern. Mr. McCune was graduated from the University of California in 1928 with a bachelor of science degree in electrical engineering and entered the employ of the General Electric Company after graduation.

W. R. Streuli (A '46) formerly in charge of hydro station engineering and power station switchgear for Brown, Boveri and Company, Ltd., Baden, Switzerland, is now with Brown Boveri Corporation, New York, N. Y. The Brown Boveri Corporation is the United States sales and service organization of the Switzerland firm.

J. W. Smith (A '40) formerly in the apparatus sales department, Canadian General Electric Company, Ltd., Windsor, Ontario, Canada, has been appointed manager of the apparatus division of the Winnipeg, Manitoba, Canada, office of that concern. Mr. Smith is a graduate of the University of British Columbia. He has been associated with the Canadian General Electric Company since 1931.

J. L. Sanders, Jr. (A '45) has not joined the Langley Memorial Aeronautical Laboratory, National Advisory Commission for Aeronautics, Langley Field, Va., as was reported erroneously in the January 1948 issue of *ELECTRICAL ENGINEERING*. Mr. Sanders is associated with the Florida Power and Light Company, Sarasota, in the capacity of division commercial manager.

W. J. Gilson (A '26, M '38) president and general manager, Eastern Power Devices Ltd., Toronto, Ontario, Canada, and past vice-president of AIEE for District 10 (Canada), has been elected chairman of the Canadian Council of Professional Engineers and Scientists for the year 1948. Mr. Gilson has been serving on this body as AIEE District 10 representative.

E. D. Phinney (M '42) general patent attorney, International Telegraph and Telephone Corporation and International Standard Electric Corporation, New York, N. Y., and vice-president and general patent attorney, Federal Telephone and Radio Corporation, Newark, N. J., has been elected a vice-president of the International Telegraph and Telephone Corporation. Mr. Phinney has been associated with that company since 1936. He is a member of the New York Patent Law Association, the American Patent Law Association, Washington, D. C., and of the Institute of Radio Engineers.

F. C. Edmondson (M '30, F '40) general manager, City of Perth (Australia) Electricity and Gas Department, has been appointed overseas representative for the Institution of Electrical Engineers in western Australia.

M. R. Seldon (A '45) formerly electrical engineer, National Advisory Committee for Aeronautics, Langley Field, Va., is now with the United Aircraft Corporation as an instrument engineer, flight test section, Chance Vought Aircraft Division, Stratford, Conn.

J. A. Whitaker (A '37) formerly design engineer, Douglas Aircraft Company, Santa Monica, Calif., is employed now as a designer, Consolidated Vultee Aircraft Corporation, San Diego, Calif.

H. A. Martin (A '20, M '26) colonel, corps of engineers, officer reserve corps, until recently post engineer for camps and stations in vicinity of Harrisburg, Pa., has been appointed manager of electrical engineering, DEVENCO, Inc., New York, N. Y.

P. S. Donnell (A '19, F '37) until recently colonel, Army of the United States, has been named vice-president of the Oklahoma Agricultural and Mechanical College, Stillwater. Mr. Donnell has been awarded the Legion of Merit, the Bronze Star Medal, the Army Commendation Ribbon, and the Order of the British Empire, in recognition of his military service.

R. O. Bell (M '47) formerly assistant engineer-in-charge, transformer sales, electrical department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been promoted to engineer-in-charge of transformer sales. Mr. Bell has been with the company since 1936, the year of his graduation from Pennsylvania State College.

Francis Hodgkinson (A '02) honorary professor of mechanical engineering, Columbia University, New York, N. Y., and retired consulting engineer for the Westinghouse Electric Corporation, recently was awarded an honorary membership in the American Society of Mechanical Engineers for his pioneer work and "outstanding achievement in the development of the steam turbine prime mover."

F. R. Lack (M '37) a director and vice-president in charge of the radio division, Western Electric Company, Inc., New York, N. Y., was one of three Bell System executives who recently received the Presidential Certificate of Merit "for outstanding fidelity and meritorious conduct in aid of the war effort against the common enemies of the United States and its Allies in World War II." **M. J. Kelly** (M '26, F '31) executive vice-president, Bell Telephone Laboratories, Inc., New York, N. Y., also was a recipient of the Certificate of Merit. The presentations were made by Secretary of the Navy, John L. Sullivan.

OBITUARY • • • •

Ralph Gordon McCurdy (A '16, M '28, F '34) director of electric apparatus development, Bell Telephone Laboratories, Inc., New York, N. Y., died recently. Born in Eureka, Calif., on January 29, 1891, he attended the University of California from

which he received a bachelor of science degree in 1913. Mr. McCurdy was employed as an engineer in the underground distribution department, Pacific Gas and Electric Company, Oakland, Calif., until September 1913, when he became a member of the field testing force for the Joint Committee on Inductive Interference of the Railroad Commission of California. He entered the employ of the American Telephone and Telegraph Company, New York, N. Y., in 1916 as a member of the staff of the transmission and protection engineer. In 1919 he was transferred to the department of development and research in the capacity of noise prevention engineer. Mr. McCurdy was promoted to the position of assistant director of transmission development in 1937 and advanced to director of transmission development in 1940. He assumed the title of director of transmission engineering in 1941 and that of director of electric apparatus development in 1944. Mr. McCurdy served on the AIEE Standards committee from 1940 to 1944 and on the AIEE communication committee from 1941 until the time of his death.

James G. Biddle (A'96) founder and chairman of the board of directors, the James G. Biddle Company, Philadelphia, Pa., died recently. He was 79 years of age. Mr. Biddle was employed for several years by firm of James W. Queen and Company, before he left his position of manager of the scientific apparatus and electric instruments department in 1895 to found his own business. He directed that business for more than 50 years and during that time was responsible for the introduction of many electric and scientific instruments to the United States. Mr. Biddle was a member of the Franklin Institute, and of the Engineers' Club of Philadelphia.

Philip Sheridan Biegler (A '07, M '13, F '29) professor emeritus of electrical engineering, University of Southern California, Los Angeles, died recently. Born on January 30, 1880, in St. Paul, Minn., he was graduated from the University of Wisconsin with a bachelor of science degree in electrical engineering in 1905. He received the degree of electrical engineer in 1915 from that institution and a master of science degree in 1916 from the University of Illinois. From 1905 to 1906, Mr. Biegler was with the engineering department of the Chicago (Ill.) Edison Company. He then was appointed an instructor and later an assistant professor of electrical engineering, State University of Iowa, Iowa City. He was employed in the engineering department of the Washington Water Power Company in 1909–10, and served as an assistant professor of electrical engineering, Purdue University, Lafayette, Ind., from 1910 to 1911. Mr. Biegler was a professor of electrical engineering at the State University of Montana, Missoula, from 1911 to 1913, when he accepted an assistant professorship at the University of Illinois, Urbana. He assumed the duties of associate editor of the magazine *Electrical World* in 1918 but resigned from that position in 1921 to accept an associate professorship at the State College of Washington, Pullman. Mr. Biegler became affiliated with the University of Southern California in 1923 as a professor of electrical engineering. He was named acting dean of the college of engineering in 1928 and dean of the college in 1930. He retired in 1947. Mr. Biegler was a member of Sigma Xi, Phi Kappa Phi, Tau Beta Pi, Eta Kappa Nu, and of the Los Angeles Engineers' Club. He served as secretary of the Los Angeles Section in 1930–31 and as chairman of that Section in 1931–32. He also served on the AIEE education committee from 1929 to 1936 and in 1940–41, and was Student Branch counselor for the University of Southern California from 1935 to 1941 and from 1943 to 1947.

Lucius Buckley Andrus (A '03, M '11, F '19) retired president, Indiana Electric Corporation, Indianapolis, died recently. Born on September 22, 1875, at Columbus, Ohio, Mr. Andrus attended Ohio State University for three years. He was graduated from the University of Notre Dame with an electrical engineering degree and later with a master of science degree. From 1899 to 1902 Mr. Andrus was superintendent of the fire alarm telegraph and police signal systems, Columbus, Ohio. In 1902 he was in the employ of the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation). Mr. Andrus left that position to take over the duties of general superintendent and chief engineer at the Indiana and Michigan Electric Company headquarters, South Bend, Ind., in 1904, and in 1917 he accepted a position with the American Public Utilities Company, Grand Rapids, Mich., as chief engineer. He then served with various public utilities in Indiana which eventually were merged to form the Public Service Company of Indiana. Mr. Andrus was named president of the Indiana Electric Corporation in 1930. He retired in 1936.

George Eaddie Bulloch (M '41) engineering department, New Jersey Bell Telephone Company, Newark, died recently. Born on August 19, 1898, at Pen Argyl, Pa., Mr. Bulloch received a bachelor of science degree from Columbia University in 1925. He was employed in June of 1927 by the New Jersey Bell Telephone Company and he remained with that organization until the time of his death. Mr. Bulloch was engaged primarily in teletypewriter engineering during his association with the Bell System.

Frank Nehrmiah Waterman (A '93, M '94, F '12) retired consulting engineer, Summit, N. J., died recently. Born in Toledo, Ohio, on October 30, 1865, Mr. Waterman received a mechanical engineering degree from Cornell University in 1889, and a master of science degree from Brooklyn Polytechnic Institute in 1907. He was associated with the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation), Pittsburgh, Pa., as an electrical engineer from 1889 to 1900 when he left that company's employ to establish a private consulting engineering business in New York, N. Y., which specialized in electrical and mechanical patent litigation. Mr. Waterman subsequently retired in 1939. He was a member of the Institute of Radio Engineers, the American Electrochemical Society, and of the American Physical Society.

Granville Ernst Palmer (F '36) president and treasurer, the Palmer Electric and Manufacturing Company, Wakefield, Mass., died recently. Born on February 1, 1869, in Providence, R. I., Mr. Palmer received his technical education at the Providence High School. He was in the employ of the Western Electric Company from 1886 until 1889 when be became associated as western electric agent with the Denver, Colo., Telephone and Power Installation. From 1894 to 1898 Mr. Palmer served as construction superintendent for the Bell Telephone Company in its Ohio, Indiana, and Illinois offices. He held the position of sales engineer for the H. C. Roberts Company, Philadelphia, Pa., from 1898 to 1900 and then was employed as an electrical engineer by the Pettingell Andrews Company, Boston, Mass. In 1910 Mr. Palmer left that concern to accept a position as sales manager for the Hart Manufacturing Company, Hartford, Conn. He founded the Palmer Electric and Manufacturing Company in 1912 and had served as president and treasurer of the organization since that time. Mr. Palmer was a member of the National Electrical Manufacturers Association, the National Electric Light Association, and of the Engineers' Club of New York.

Newitt Jackson Neall (A '03, M '08, F '12) consulting engineer, Boston, Mass., died recently. Born on February 7, 1875, in Philadelphia, Pa., Mr. Neall was graduated from the Massachusetts Institute of Technology in 1900 with a bachelor of science degree after previously having attended a special student's course of the Pennsylvania Railroad Company, Altoona, Pa., from 1892 to 1896. Mr. Neall was associated with the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation), Pittsburgh, Pa., from 1900 to 1906. He was a special student on lightning protective apparatus development, design, and application, for the first seven months and then served as an assistant in that department. In 1903 he was put in charge of the lightning arrester department and in 1905 named section engineer of the engineering department. In 1906 Mr. Neall left that organization to start a business as a consulting engineer in Boston, Mass. He became part of the partnership known as Thomas and Neall in 1907 and was engaged in similiar work. The partnership was dissolved sev-

eral years later and Mr. Neall returned to his private consulting business which he carried on until the time of his death.

Howard Walker Dexter, Jr. (A '26, M '46) director, power and steam utilization division, Duquesne Light Company, Pittsburgh, Pa., died recently. Born in Valdosta, Ga., on June 20, 1902, Mr. Dexter was graduated from the Massachusetts Institute of Technology in 1923 with a bachelor of science degree in electrical and mechanical engineering. He accepted a position with the West Penn Power Company, Pittsburgh, in 1923 and remained with that organization until 1925. Mr. Dexter served as an assistant to the electrical engineer, H. C. Fugate Engineering Company, West Palm Beach, Fla., from 1925 to 1926 when he became associated with George W. Goethals, Inc., West Palm Beach. He accepted a position as senior sponsor engineer, eastern section, sales engineering department, Duquesne Light Company in 1927, and was named to the same capacity in the electric installation section in 1932. He was promoted to the position he held at the time of his death in 1939. Mr. Dexter was a member of the American Society of Mechanical Engineers.

MEMBERSHIP ••

The board of examiners, at its meeting of January 15, 1948, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Dana, A. S., chief engr., & technical director, The Kerite Co., Seymour, Conn.
Pattison, D. R., system elec. engr., Pennsylvania Electric Co., Johnstown, Pa.
Redding, C. S., pres., Leeds & Northrup Co., Phila., Pa.

3 to grade of Fellow

To Grade of Member

Barbrow, L. E., elec. engr., National Bureau of Standards, Washington, D. C.
Bartholomew, D., asst. prof., Univ. of Arizona, elec. engg. dept., Tucson, Ariz.
Bowman, C. F., engr., Commonwealth Edison Co., Chicago, Ill.
Brighty, W. B., design engr., mot. & gen. engr. div., General Electric Co., Fort Wayne, Ind.
Bryant, C. K., Sr., pres., Bryant Elec. Repair Co., Inc., Gastonia, N. C.
Busch, F. H., asst. to div. engr.; meter engg. div., General Electric Co., Lynn, Mass.
Callard, N. H., genl. mgr., Hilo Electric Light Co., Hilo, Hawaii
Carlson, E. G., plant engr., The Bell Tel. Co. of Penna., Phila., Pa.
Cooter, I. L., physicist, National Bureau of Standards, Washington, D. C.
Daly, T. A., section engr., ordnance div., Westinghouse Elec. Corp., Sharon, Pa.
Darlington, B. N., transmission engr., Peninsular Tel. Co., Tampa, Fla.
Depp, W. A., member of technical staff, Bell Telephone Labs., Inc., New York, N. Y.
Foster, W. S., chief, engg. section, All-Weather Flying Div., CCAAF, Wilmington, Ohio.
Heiney, C. H., engr., General Electric Co., Jackson Mich.
Jacobson, A. W., charge of elec. dev. & design, The Bristol Co., Waterbury, Conn.
Johnson, S. E., engr., lamp dept., General Electric Co., Cleveland, Ohio
Johnston, J. A., mgr., Tri-County Electric Co-operative, Leesburg, Va.
Kolke, R. H., assoc. elec. engr., Cincinnati Gas & Electric Co., Cincinnati, Ohio
Lawrence, J. D., asst. div. mgr., Appalachian Electric Power Co., Roanoke, Va.
Lee, W. H., electrical squad leader, Design Service Co., Cleveland, Ohio
Lommen, M. A. K., instructor, elec. engg. dept., North Dakota Agricultural College, Fargo, N. D.
McLaughlin, H. R., senior elec. engr., assembly & repair dept., Naval Air Station, Alameda, Calif.
Millar, W., dist. engr., Canadian Westinghouse, Vancouver, B. C., Canada
Miller, R. B., senior engr., Iowa-Illinois Gas & Electric Co., Rock Island, Ill.
Muszynski, E. L., associate of Thomas T. Lunde, Associates, San Francisco, Calif.
Plank, H. G., elec. engr., Manitowoc Public Utilities, Manitowoc, Wis.
Power, R. B., Jr., Prof. of engg. research, Pennsylvania State College, Pa.
Prior, A. H., elec. engr., NACA Flight Propulsion Lab., Cleveland Airport, Ohio
Ruwell, R. G., engr., executive operating dept., Bell Tel. Co. of Pa., Phila., Pa.
Scheibe, W. K., ch. elec. engr., Mauricio Hochschild, S.A.M.I., Pulacayo, Bolivia, S. A.
Schell, L. S., Jr., elec. engr., General Electric Co., Pittsfield, Mass.
Schlick, A. M., elec. engr., Ebasco Services, Inc., New York, N. Y.
Scott, A. H., physicist, National Bureau of Standards, Washington, D. C.
Seddon, R. E., elec. engr., E. I. du Pont de Nemours & Co., Wilmington, Del.
Slauer, R. G., Mgr., application lab., Sylvania Electric Products, Inc., Salem, Mass.
Wilson, W. R., developmental engr., General Electric Co., Pittsfield, Mass.
Winter, A. F., staff asst., C & P Tel. Co. of West Virginia, Charleston, W. Va.

37 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before March 21, 1948, or May 21, 1948, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Fellow

Acuna, E. R., Ericsson Tel. Enterprise, Mexico, D. F.
1 to grade of Fellow

To Grade of Member

Ansel, L. V., Chevrolet Gear & Axle, Detroit, Mich.
Begor, C. R., Jr., Natl. Lead Co., Tahawus, N. Y.
Black, P. M., Ill. Northern Utilities Co., Dixon, Ill.
Buckland, F. F. (Mrs.), General Elec. Co., Schenectady, N. Y.
Burrill, H. G., (re-election), 11 East 21st St., Baltimore, Md.
Chidlow, E., The Engineering Design Co., Shrewsbury, Salop, England
Crothers, J. M., Catalytic Construction Co., Philadelphia, Pa.
Ditlow, G. K., Rural Electrification Admin., Washington, D. C.
Dubash, M. D., Karachi Elec. Supply Corp., Ltd., Karachi, India
Erickson, O. P., Erickson Engg. Co., Tampa, Fla.
Everson, H. K., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Finley, J. T., Jr., James R. Kearney Corp., St. Louis, Mo.
Grunsky, C., Coast Counties Gas & Elec. Co., San Francisco, Calif.
Hagopian, R. H., Westinghouse Elec. Corp., Baltimore, Md.
Harmon, F. L., Pacific Islands Engineers, Station 10, Guam
Harvey, J. O., East Bay Municipal Utility Dist., Oakland, Calif.
Hayworth, D. F., Western Elec. Co., Chicago, Ill.
Henry, F. G., H. W. Beecher, Seattle, Wash.
Hill, E. L., Bechtel Corp., Los Angeles, Calif.
Hogan, A. L., Jr., Kirbyville Light & Power Co., Houston, Tex.
Horn, M. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Imburgia, C. A., American Gas & Elec. Service Corp. New York, N. Y.
Jewell, R. R., Wheeling Elec. Co., Wheeling, W. Va.
Lee, R. H., E. I. du Pont de Nemours & Co., Wilmington, Del.
Lewis, G. A., Bureau of Reclamation, Billings, Mont.
Loebenstein, J., Radio Receptor Co., Inc., New York, N. Y.
Luce, C. B., General Elec. Co., c/o Trumbull Elec. Mfg. Co., North Hollywood, Calif.
Manion, R. K., Kaiser-Frazer Corp., Willow Run, Mich.
McBennett, J. F., N. Y. State Elec. & Gas Corp., Elmira, N. Y.
Moy, G., Ta Tung Industrial & Dev. Co. of Shanghai, P. O. Box 452, New York, N. Y.
Oldenburg, P. R., Pacific Power & Light Co., Portland, Oreg.
Pankhurst, F. A., Canadian Wire & Cable Co., Ltd., Leaside, Ontario, Canada
Petrie, J. N., Automatic Elec. Sales Corp., Chicago, Ill.
Quarterman, A. M., Yonge & Hart, Pensacola, Fla.
Rivoira, E. J., The Cincinnati Milling Machine Co. Cincinnati, Ohio
Russell, H. A. (re-election), Toronto Hydro-Electric System, Toronto, Ontario, Canada
Rypinski, C. A., Sr., City of Pasadena, Pasadena, Calif.
Sillman, I. D., (re-election), Hensol Elec. Corp., New York, N. Y.
Smith, A. C., Cdr. USN, Bureau of Ships, Washington, D. C.
Smith, E. B., Canadian Comstock Co., Ltd., Montreal Quebec, Canada
Stephens, L. R., Florida Power & Light Co., Miami, Fla.
Upton, E. F., Jr., Brown Instrument Co., Philadelphia, Pa.
Webb, L. W., General Elec. Co., Erie, Pa.
Wehe, R. A., California Public Utilities Comm., San Francisco, Calif.
Zachmann, H. C., 294 Montgomery St., Bloomfield, N. J.

45 to grade of Member

To Grade of Associate

United States, Canada, Mexico, and Puerto Rico

1. North Eastern

Aitchison, T. C., General Elec. Co., Pittsfield, Mass.
Alexander, E. U., Buffalo Niagara Elec. Corp., Buffalo, N. Y.
Anderson, K. O., General Elec. Co., Schenectady, N. Y.
Beau, J. F., Eastman Kodak Co., Rochester, N. Y.
Bonanno, J. W., Mass. Inst. of Tech., Cambridge, Mass.
Brandt, D. B., General Elec. Co., West Lynn, Mass.
Bromley, D. L., General Elec. Co., Schenectady, N. Y.
Burt, E. W., Eastman Kodak Co., Rochester, N. Y.
Carlson, R. T., Connecticut Light & Power Co., Waterbury, Conn.
Darsie, G. A., General Elec. Co., Pittsfield, Mass.
Flocken, R. J., General Elec. Co., Pittsfield, Mass.
Harms, H. B., General Elec. Co., Schenectady, N. Y.
Haselton, F. W., The Century Indemnity Co., Hartford, Conn.
Heller, P. N., General Elec. Co., Schenectady, N. Y.
Helterline, L. L., Jr., Sorensen & Co., Inc., Stamford, Conn.
Hodgin, W., General Elec. Co., Schenectady, N. Y.
Huetsch, Oswald F., N. Y. State Elec. & Gas Corp., Binghamton, N. Y.
Hughes, R. L., Vincent J. Brown Co., Buffalo, N. Y.
Jennings, S. J., General Elec. Co., Schenectady, N. Y.
Lisk, O. W., Eastman Kodak Co., Rochester, N. Y.
Murray, T. A., Jr., Univ. of Maine, Orono, Me.
O'Brien, R. C., Allis-Chalmers Mfg. Co., Boston, Mass.
Parziale, A. J., Mass. Inst. of Tech., Cambridge, Mass.
Peterson, A. P., New England Tel. & Tel. Co., Lewiston, Me.
Prudent, G. H., General Elec. Co., Schenectady, N. Y.
Radke, D. F., General Elec. Co., Pittsfield, Mass.
Robinson, P. B., General Elec. Co., Schenectady, N. Y.
Sarwate, V. V., Dept. of Elec. Engg., Cornell Univ., Ithaca, N. Y.
Schlehuber, R. C., General Elec. Co., Schenectady, N. Y.
Schmitzer, R. W., General Elec. Co., Schenectady, N. Y.
Sheets, M. W., General Elec. Co., Schenectady, N. Y.
Smith, J. A., General Elec. Co., Pittsfield, Mass.
Smith, J. K., General Elec. Co., Schenectady, N. Y.
Springer, E. W., General Elec. Co., Pittsfield, Mass.
Springgate, W. F., General Elec. Co., Pittsfield, Mass.
Steffy, W. E., N. Y. State Elec. & Gas Corp., Elmira, N. Y.
Thode, J. G., General Elec. Co., Schenectady, N. Y.
Wakefield, K. E., General Elec. Co., Schenectady, N. Y.
White, E. N., Jr., Mass. Inst. of Tech., Cambridge, Mass.
Wolfson, J. A., Workshop Assocs., Inc., Newton Highlands, Mass.
Woodward, J. S., Jr., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.

2. Middle Eastern

Abell, D. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Allen, V. I., Heyden Chemical Corp., Morgantown, W. Va.
Bartage, C. M., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Booth, J., Electric Storage Battery Co., Philadelphia, Pa.
Borland, M. H., Jr., The Mead Corp., Chillicothe, Ohio
Brown, W. C., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Bryan, J. R., General Elec. Co., Erie, Pa.
Buffington, C. E., American Tel. & Tel. Co., Pittsburgh, Pa.
Calender, D. E., Clark Controller Co., Cleveland, Ohio
Carr, R. F., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Crom, H. D., Pittsburgh Plate Glass Co., Barberton, Ohio
Croucher, W. C., Jr., Glenn L. Martin Co., Baltimore, Md.
Crout, W. R., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Cybulski, J., Naval Research Lab., Anacostia Station, Washington, D. C.
Daub, L. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Darrow, K. G., General Elec. Co., Philadelphia, Pa.
Forrest, W., Columbia Malleable Castings Corp., Columbia, Pa.
Frantti, E. W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Ganoe, B. A., Chester Vocational School, Chester, Pa.
Garrett, W. O., Glenn L. Martin Co., Baltimore, Md.
Geary, L. W., U. S. Naval Gun Factory, Washington, D. C.
Geiselman, R. A., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Gillespie, P. R., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Gundel, H. F., Bell Tel. Co., Pittsburgh, Pa.
Hall, D. E., American Tel. & Tel. Co., Philadelphia, Pa.
Hartman, N. L., American Tel. & Tel. Co., Pittsburgh, Pa.
Hendron, E. W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Higgs, R. W., Howard Univ., Washington, D. C.
Hopkinson, F. W., Electric Storage Battery Co., Philadelphia, Pa.
Ibrahim, B. M., Bureau of Standards, Washington, D. C.
Idzkowski, R. J., Westinghouse Elec. Co., E. Pittsburgh, Pa.
Johnson, H. E., General Elec. Co., Philadelphia, Pa.
Johrde, P. S., Elliott Co., Ridgway, Pa.
Kessler, J. R., Firestone Tire & Rubber Co., Akron, Ohio
Knapp, M. S., North Electric Mfg. Co., Galion, Ohio
Koledin, E., Sharon Steel Corp., Sharon, Pa.
Krafft, H. C., Jr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Lange, J. E., Duquesne Light Co., Pittsburgh, Pa.
Latson, R. C., Kelley-Koett Mfg. Co., Cincinnati, Ohio
Laube, H. D., General Elec. Co., Pittsfield, Mass.
Leonard, H. R., Western Elec. Co., Baltimore, Md.
Lindstrom, T., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Litrides, S. J., Pennsylvania Power & Light Co., Allentown, Pa.
Lombard, R. A., American Tel. & Tel. Co., Philadelphia, Pa.
Luiggi, H. L., Pennsylvania R. R., E. Altoona, Pa.
Lyon, H. A., Westinghouse Elec. Corp., Pittsburgh, Pa.
MacDonald, E. H., Philadelphia Elec. Co., Philadelphia, Pa.
Mathias, R. A., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
May, R. C., Clark Controller Co., Cleveland, Ohio
McGraw, A. P., Trumbull Elec. Mfg. Co., Philadelphia, Pa.
Mitchell, L. C. (re-election), L. Clair Mitchell Co., Pittsburgh, Pa.
Monaghan, W. J., Jr., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Morris, E. W., General Elec. Co., Philadelphia, Pa.
Murphy, J. R., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Nelson, P. E., The Toledo Edison Co., Toledo, Ohio
Parmentier, G. L., E. I. du Pont de Nemours, Wilmington, Del.
Pase, H. A., Jr., Heyden Chemical Corp., Morgantown, W. Va.
Perecinic, W. S., Philco Corp., Philadelphia, Pa.
Plath, R. H., Elec. Controller & Mfg. Co., Cleveland, Ohio
Porter, T. J., The Elec. Tachometer Corp., Philadelphia, Pa.
Ramage, W. W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Regan, E. D., Univ. of Pennsylvania, Upper Darby, Pa.
Rhodes, R. K., Duquesne Light Co., McKeesport, Pa.
Rowley, J. M., Wheeling Steel Corp., Steubenville, Ohio
Rydgren, D. A., Delaware Power & Light Co., Wilmington, Del.
Schober, G. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Schultz, R. B., Elliott Co., Ridgway, Pa.
Seip, H. S., American Tel. & Tel., Harrisburg, Pa.
Shoemaker, J. A., Westinghouse Elec. Corp., Sharon, Pa.
Slater, R. J., Clark Controller Co., Cleveland, Ohio
Smith, R. L., Duquesne Light Co., Pittsburgh, Pa.
Spear, E. F., Delaware Power & Light Co., Wilmington, Del.
Spielman, S. C. (re-election), Philco Corp., Philadelphia, Pa.
Stauffer, J. R., Philadelphia Elec. Co., Philadelphia, Pa.
Stiegman, L. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Stillman, G. I., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Stone, W. W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Tate, R. V., Aircraft-Marine Products Inc., Philadelphia, Pa.
Unger, R. W., E. L. Wiegand Co., Pittsburgh, Pa.
Vodar, J., Jr., E. I. du Pont de Nemours & Co., Belle, W. Va.
Wagner, D. M., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Walko, K. L., Jack & Heintz Precision Industries, Inc., Bedford, Ohio
Warreck, A., American Tel. & Tel. Co., Pittsburgh, Pa.
Welz, A. E., Clark Controller Co., Cleveland, Ohio
Wendlandt, C. W., General Elec. Co., Erie, Pa.
Westendorf, E. U., General Elec. Co., Dayton, Ohio
Wilcox, H. K., Jr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Willey, H. C., Intl. Nickel Co., Inc., Huntington, W. Va.
Woo, C. H., Reliance Elec. & Engg., Cleveland, Ohio
Yocum, H. E., Jr., Bell Tel. Co. of Pennsylvania, Philadelphia, Pa.
Zelkovic, M. J., Allis-Chalmers Mfg. Co., N. S. Pittsburgh, Pa.
Zimmerman, H. F., Taylor-Winfield Corp., Warren, Ohio

3. New York City

Allentuck, J., James A. Tuck, New York, N. Y.
Alster, S., Board of Transportation, New York, N. Y.
Anderson, T. N., Intercontinent Engg. Corp., New York, N. Y.
Antonazzi, M., Bendix Aviation Corp., Teterboro, N. J.
Behnken, R. W., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Belfi, J. L., Bell Tel. Labs., New York, N. Y.
Berrien, R. C., American Broadcasting Co., Inc., New York, N. Y.
Bialo, J. M., American District Telegraph Co., New York, N. Y.
Blackman, S. R., Eastern Inspection Bureau, New York, N. Y.
Bridgman, D. S., American Tel. & Tel. Co., New York, N. Y.
Byrne, E. J., Gibbs & Hill, New York, N. Y.
Churko, J. G., Board of Transportation, New York, N. Y.
Daum, A., Board of Transportation, New York, N. Y.
Decker, H., Public Service Elec. & Gas Co., Newark, N. J.
Deltoro, V., City College of N. Y., New York, N. Y.
Dolin, R., New York Univ., Bronx, N. Y.
Dubbs, R. B., American Tel. & Tel. Co., Newark, N. J.
Eisenberg, I., I.B.M. Corp., New York, N. Y.
Euler, R., Gibbs & Cox, Inc., New York, N. Y.
Farber, M. M., Devenco, Inc., New York, N. Y.
Franklin, R. E., General Elec. Co., Newark, N. J.
Friedrich, A. C., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Frisch, F. W., Federal Telecommunication Labs., Nutley, N. J.
Henning, R. E., Sperry Gyroscope Co., Lake Success, L. I., N. Y.
Klosin, J. J., Jr., Burndy Engg. Co., Inc., Bronx, New York, N. Y.
Kouvelites, J. S., Federal Telecommunication Labs., Nutley, N. J.
Leibowitz, R. C., 1460 Vyse Ave., New York, N. Y.
Lewis, M., Dictograph Products Corp., Jamaica, N. Y.
Litwack, B., Western Elec. Co., Newark, N. J.
Longo, C. V., Rutgers Univ., New Brunswick, N. J.
McLellan, J. D. (re-election), J. H. Bunnell & Co., Brooklyn, N. Y.
McMillin, R. R., RCA Communications, Inc., New York, N. Y.
Meyer, E. G., Sylvania Elec. Products Inc., Flushing, N. Y.
Monsees, J., Westchester Lighting Co., Mt. Vernon, N. Y.
Nissen, J. H., Board of Transportation, New York, N. Y.
O'Connor, B. J., Bendix Aviation, Teterboro, N. J.
O'Connor, J. J., McGraw-Hill Publishing Co., New York, N. Y.
Petker, A., H. K. Ferguson Co., Inc., New York, N. Y.
Piccot, A. R., Atomic Energy Comm., New York, N. Y.
Roundy, T. S., Intl. Tel. & Tel. Corp., New York, N. Y.
Sackler, A. A., Ebasco Services, Inc., New York, N. Y.
Sanger, K. E., American Gas & Elec. Service Corp., New York, N. Y.
Scism, W. A., Ward Leonard Elec. Co., Mount Vernon, N. Y.
Slevin, J. J., The Miller Co., New York, N. Y.
Sobel, J., Western Elec. Co., Inc., Newark, N. J.
Szabados, R. L., Wendel Elec. Mach. Co., Brooklyn, N. Y.
Vacca, L. N., Arma Corp., New York, N. Y.
Van Duzee, R. M., American Tel. & Tel. Co., New York, N. Y.
Weinstein, D., 2726 Valentine Ave., Bronx, N. Y.
Wenzel, S. E., E. I. du Pont de Nemours & Co., Pennsgrove, N. J.
Wolf, E. G., Pratt Institute, Brooklyn, N. Y.
Zemanian, A. H., College of the City of N. Y., New York, N. Y.
Zervas, W. O., American Iron & Steel Inst., New York, N. Y.

4. Southern

Allen, T. J., Georgia Power Co., Atlanta, Ga.
Bragg, C. C., Industrial Elec. Co., Clarksburg, W. Va.
Dailey, G. E., Jr., General Elec. Co., Miami, Fla.
Delano, G. M., Dept. of Public Utilities, Richmond, Va.
Dickson, J. R., Westinghouse Elec. Corp., Charlotte, N. C.
Drysdale, W. A., Southern Bell Tel. & Tel. Co., New Orleans, La.
Ely, R. G., Jr., Knoxville Utilities Board, Knoxville, Tenn.
Foreman, H. P., Alabama Power Co., Greenville, Ala.
Grannis, C. O., M. Connell & Assocs., Miami, Fla.
Haak, A. E., Louisiana Power & Light Co., Gretna, La.
Harris, R. C., Mississippi State College, State College, Miss.
Hochdorf, M., TVA, Chattanooga, Tenn.
Horne, J. W., Graybar Elec. Co., Jacksonville, Fla.
Hoskins, R. S., TVA, Chattanooga, Tenn.
Ingraham, C. S., Sperry Gyroscope Co., Inc., Norfolk, Va.
Jackson, D. H., B. O. Vannort, Charlotte, N. C.
James, W. G., Clinton Nat'l Labs., Oak Ridge, Tenn.
Kyle, H. A., Jr., TVA, Knoxville, Tenn.
Lowry, D. G., American Air Filter Co., Inc., Louisville, Ky.
Madlon, E. A., I.B.M., Raleigh, N. C.
Mathews, L. O., Jr., Mathews Elec. Service, Tuscaloosa, Ala.
McClellan, F. R., General Elec. Co., Jacksonville, Fla.
Menk, K. L., Alabama Power Co., Birmingham, Ala.
Michel, E. W., Univ. of South Carolina, Columbia, S. C.
Millsaps, J. B., Aluminum Co. of America, Alcoa, Tenn.
Nix, R. P., Southwestern Gas & Elec. Co., Shreveport, La.
Proffitt, C. Y., B. O. Vannort, Charlotte, N. C.
Schoonmaker, L. E. (re-election), Univ. of Florida, Gainesville, Fla.
Schultz, W. D., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Sizemore, J. D., Mississippi Power & Light Co., Greenville, Miss.
Smith, E. H., Robert & Co., Assoc., Atlanta, Ga.
Troy, E. F., Jr., Westinghouse Elec. Corp., Atlanta, Ga.
Watson, G. P., Kendall Mills, Paw Creek, N. C.
Webster, C. R., Westinghouse Elec. Corp., Raleigh, N. C.
Whitmire, C. N., Florida Power & Light Co., Ft. Pierce, Fla.
Williams, R. S., Atlantic Refining Co., Bude, Miss.
Yancey, C. T., City of Waynesboro, Va.

5. Great Lakes

Adelson, M., Univ. of Illinois, Champaign, Ill.
Bashe, C. J., Purdue Univ., West Lafayette, Ind.
Berger, R. L., Public Service Co. of Northern Illinois, Joliet, Ill.
Boettcher, H. P., Univ. of Wisconsin, Madison, Wis.
Bremer, E. V., Western Elec. Co., Chicago, Ill.
Carapanos, G. E., Illinois Power Co., Galesburg, Ill.
Carnegie, W. G., Jr., Roberts & Schaefer Co., Chicago, Ill.
Chatterjee, A. K., Univ. of Illinois, Champaign, Ill.
Crisler, E. J., Rock Island Improvement Co., Peoria, Ill.
Davis, E. H., Foster Elec. Co. Peoria, Ill.
Drechsel, L. A., General Elec. Co., Ft. Wayne, Ind.
DuFresne, H. J., Allis-Chalmers Mfg. Co., West Allis, Wis.
Duros, C. J., Pioneer Service & Engg. Co., Chicago, Ill.
Eggleston, J. H., Automatic Elec. Co., Chicago, Ill.
Ehrlich, R. W., American Tel. & Tel. Co., Chicago, Ill.
Epp, A., Jr., General Motors Corp., Flint, Mich.
Fleites, M. O., Commonwealth & Southern Corp., Jackson, Mich.
Foley, C. F., Central Illinois Public Service Co., Springfield, Ill.
Franzmann, D. R., Northern States Power Co., Eau Claire, Wis.
Freeman, J. R., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Gross, E. S., Automatic Elec. Co., Chicago, Ill.
Hall, G. T., Rural Electrification Administration, Ames, Iowa

Hitt, G. L., Illinois Central R. R., Chicago, Ill.
Holland, J., General Motors Corp., Flint, Mich.
Howell, W. S., Illinois Bell Tel. Co., Joliet, Ill.
Huber, R. D., Joslyn Mfg. & Supply Co., Chicago, Ill.
Hurt, Z. C., Western Elec. Co., Chicago, Ill.
Hutchinson, D. J., Jr., Lear, Inc., Grand Rapids, Mich.
Jordan, J. R., Indianapolis Power & Light Co., Indianapolis, Ind.
Jordan, R. H., Indianapolis Power & Light Co., Indianapolis, Ind.
Kalra, S. N., Univ. of Illinois, Urbana, Ill.
Kremser, A. W. (re-election), Allis-Chalmers Mfg. Co., Davenport, Iowa
Kulp, B. A., Carnegie-Illinois Steel Corp., Chicago, Ill.
Larson, R. G., Commonwealth Edison Co., Chicago, Ill.
LeBosquet, R. J., Wisconsin Power & Light Co., Beaver Dam, Wis.
Lee, N. R., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Lyneis, H. W., Square D Company, Milwaukee, Wis.
MacWilliams, R. W., Allis-Chalmers Mfg. Co., West Allis, Wis.
Martin, F. J., Western Elec. Co., Chicago, Ill.
Mattern, R. M., American Tel. & Tel. Co., Indianapolis, Ind.
McComb, H., Public Service Co. of Northern Illinois, Chicago, Ill.
Mickelsen, H. E., Jr., Johns-Manville Products Corp., Waukegan, Ill.
Moran, J. H., Jr., Allis-Chalmers Mfg. Co., West Allis, Wis.
Muehrer, N. E., Northern Indiana Public Service Co., Hammond, Ind.
Olson, R. G., Rose Polytechnic Inst., Terre Haute, Ind.
Oman, N. W., Acme Appliance Co., Rockford, Ill.
Pfeifer, L. E., Square D Co., Milwaukee, Wis.
Prescott, R. H., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Quady, E. R., Engg. Research Associates, St. Paul, Minn.
Rangeler, L. V., Redmond Co., Inc., Owosso, Mich.
Reilly, M. J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Reinhold, H. E., Wisconsin Tel. Co., Milwaukee, Wis.
Ritter, L. J., Michigan Bell Tel. Co., Detroit, Mich.
Robinson, J. G., State Water Conservation Board, Helena, Mont.
Roesch, M. W., Rose Polytechnic Inst., Terre Haute, Ind.
Sadler, D. R., Univ. of Michigan, Ann Arbor, Mich.
Selby, R. E., Central Illinois Light Co., Peoria, Ill.
Slack, W. E., Commonwealth Edison Co., Chicago, Ill.
Sopkin, L., Chicago Sanitary Dist., Chicago, Ill.
Staub, G. A., Indianapolis Power & Light Co., Indianapolis, Ind.
Storm, J. F., Univ. of Minnesota, Minneapolis, Minn.
Strosberg, G. G., Columbia Mills, Inc., Saginaw, Mich.
Sybenga, P. M., Engg. Research Associates, St. Paul, Minn.
Szymanski, E. A., Wayne Univ., Detroit, Mich.
Tabor, P. M., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Taylor, B. C., Illinois Northern Utilities Co., Dixon, Ill.
Ugelstad, H. K., Northern States Power Co., Fargo, N. Dak.
Utley, E. J., Kellogg Co., Battle Creek, Mich.
Vineyard, H. J., General Elec. Co., Ft. Wayne, Ind.
Walston, C. E., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Zakariasen, W. R., General Motors Corp., Flint, Mich.

6. North Central

Ahmad, M., U. S. Bureau of Reclamation, Denver, Colo.
Christolear, L. K., Elec. Dept., City of Lamar, Colo.
Nelson, J. O., Corps of Engineers, Omaha, Nebr.

7. South West

Abitz, H. E., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Aldape, C. V. (re-election), Planta Electrica Grupo Industrial, Monterrey, N. L., Mexico
Andrew, E. H., Texas A. & M. College, College Station, Tex.
Bain, B. T., General Elec. Co., San Antonio, Tex.
Bair, M. Z., Jr., Westinghouse Lamp Div., Little Rock, Ark.
Barb, E. C., Graybar Elec. Co., Inc., Wichita, Kans.
Barhorst, F. B., Southwestern Bell Tel. Co., St. Louis, Mo.
Brummal, R. H., Southwestern Public Service Co., Amarillo, Tex.
Bunt, R. M., The General Supply Co., S. A., Mexico, D. F., Mexico
Chenoweth, R. D., Texas A. & M. College, College Station, Tex.
Coleman, W. O., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Donnell, G. R., Texas Power & Light Co., Dallas, Tex.
Dunn, H. D., Burrus Mill & Elevator Co., Ft. Worth, Tex.
Esparza, C. F., Mexican Tel. & Tel. Co., Mexico, D. F., Mexico
Ferguson, W. F., Univ. of Houston, Houston, Tex.
Flath, J. C. A., Southwestern Bell Tel. Co., Dallas, Tex.
Ford, D. G., Central Power & Light Co., Victoria, Tex.
Friton, E. E., James R. Kearney Corp., St. Louis, Mo.
Goodman, D. J., Armistead & Goodman, St. Louis, Mo.
Gomez, O. J., "Direccion General de Electricidad," Mexico, D. F., Mexico
Hampton, J. D., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Hoover, L. E., Union Elec. Co., St. Louis, Mo.
Jameson, S. G., Kansas City Power & Light Co., Kansas City, Mo.
Kazarovich, S. A., The H. K. Ferguson Co., Houston, Tex.
Kibler, J. B., Jr., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Lawver, E. A., Shell Chemical Co., Houston, Tex.
Lenz, L. L., Humble Oil & Refining Co., Kingsville, Tex.
Lins, T. P., Carter Oil Co., Tulsa, Okla.
Mano, J. A., Paul Berry, Inc., Little Rock, Ark.
Marnoch, G. W., City Public Service Board, San Antonio, Tex.
McConnell, H. E., H. K. Ferguson Co., Houston, Tex.
McCormick, W. M., Western Union Tel. Co., Dallas, Tex.
Metcalfe, T. C., Foshee Elec. Co., Ft. Worth, Tex.
Miller, E. H., Missouri School of Mines, Rolla, Mo.
Miller, J. J., General Elec. Co., St. Louis, Mo.
Mohr, B. B., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Mudd, R. G., James R. Kearney Corp., St. Louis, Mo.
Napier, R. H., Moloney Elec. Co., St. Louis, Mo.
Pautler, R. E., American Tel. & Tel. Co., St. Louis, Mo.
Reed, H. M., Jr., Intl. Paper Co., Cullendale, Ark.
Roberts, L. J., Southwestern Public Service Co., Amarillo, Tex.
Robertson, R. I., Kansas City Power & Light Co., Kansas City, Mo.
Rodesney, F., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Sherman, H. S. (re-election), General Elec. Co., St. Louis, Mo.
Simmons, D. E., Houston Lighting & Power Co., Houston, Tex.
Soergel, D. G., Washington Univ., St. Louis, Mo.
Stack, W. E., Monsanto Chemical Co., St. Louis, Mo.
Stanton, H. H., Texas Power & Light Co., Dallas, Tex.
Stribling, J. L., Jr., Texas Tech. College, Lubbock, Tex.
Teague, A. C., Okla. Gas & Elec. Co., Oklahoma City, Okla.
Vazquez, T. F., "Direccion General De Electricidad," Mexico, D. F., Mexico
Vickery, A. E., Brazos River Transmission Elec. Cooperative, Inc., Waco, Tex.
Walker C., L. D., "Direccion General De Electricidad," Mexico, D. F., Mexico.
Wall, R. F., Texas A. & M. College, College Station, Tex.
Walls, H. M., Southwestern Gas & Elec. Co., Longview, Tex.
Ward, J. H., Southwestern Gas & Elec. Co., Texarkana, Tex.
Watkins, L. D., Southwestern Public Service, Plainview, Tex.
Wechsler, K., Wagner Elec. Corp., St. Louis, Mo.
Weldon, F. J., Jr., Lower Colorado River Authority, Austin, Tex.
Winters, H. J., Kansas Gas & Elec. Co., Independence, Kans.
Worley, W. P., Jr., Graybar Elec. Co., Houston, Tex.
Wynn, W. R., Clay County Elec. Corp., Corning, Ark.

8. Pacific

Anderson, J. E., Metropolitan Water Dist. of Southern California, Los Angeles, Calif.
Archer, H. A., Utilities Commission, San Francisco, Calif.
Aubry, J. D., 449 W. Washington St., Sunnyvale, Calif.
Bristow, T. G., Bureau of Light, Heat & Power, San Francisco, Calif.
Bumsted, E. J., North American Aviation, Inglewood, Calif.
Bushey, G. A., Dept. of Water & Power, Los Angeles, Calif.
Cantrell, C. L., Ralph E. Phillips, Los Angeles, Calif.
Chan, E. S., State of California, Sacramento, Calif.
Coggins, R. L., Salt River Valley Water Users Assn., Phoenix, Ariz.
Crater, T. V., California Inst. of Tech., Pasadena, Calif.
Dean, C. A., Jr., Pacific Gas & Elec. Com., Sacramento, Calif.
Elliott, D. T., 729 Mission St., San Francisco, Calif.
Elliott, G. L., Northrop Aircraft Inc., Hawthorne, Calif.
Ellis, A. R., Airborne Instruments Lab., Burbank, Calif.
Gilbertson, A. T., Natl. Schools, Los Angeles, Calif.
Heer, F. A., Pacific Tel. & Tel. Co., San Francisco, Calif.
Harm, W. R., Sun Valley Elec. Mfg. Co., Phoenix, Ariz.
Harrigan, J. L., Hoffman Radio Corp., Los Angeles, Calif.
Harris, V. W., Bureau of Light, Heat & Power, San Francisco, Calif.
Larson, H. E., (re-election), Univ. of California, Berkeley, Calif.
Lear, J. B., Dept. of Public Utilities, Alameda, Calif.
Lincoln, D. C., Consolidated Vultee Aircraft Corp., San Diego, Calif.
Mezzatesta, F., Westinghouse Elec. Corp., Los Angeles, Calif.
Nielsen, D., Pacific Gas & Elec. Co., Fresno, Calif.
Pointen, E. J., U. S. Naval Supply Depot, San Pedro, Calif.
Pooler, M. A., Jr., General Elec. Co., San Francisco, Calif.
Rathbun, G. B., Westinghouse Elec. Corp., Emeryville, Calif.
Reimann, P. J., Elec. Facilities Inc., Emeryville, Calif.
Smith, R. A., Consolidated Vultee Aircraft Corp., San Diego, Calif.
Stensgaard, C. P., Jr., Hughes Aircraft Co., Culver City, Calif.
Stott, R. L., Pacific Gas & Elec. Co., San Francisco, Calif.
Swanson, W. V., Pacific Gas & Elec. Co., San Francisco, Calif.
Van Horn, J. W., A. O. Smith Corp., Los Angeles, Calif.
Weaver, R. C., C. F. Braun & Co., Alhambra, Calif.

9. North West

Averill, L. J., City of Tacoma, Tacoma, Wash.
Brown, C. L., Pacific Power & Light Co., Portland, Oreg.
Bull, G., Jr., Puget Sound Power & Light Co., Seattle, Wash.
Carter, H. G., Puget Sound Power & Light Co., Bremerton, Wash.
Coleman, M. J., Jr., Pacific Power & Light Co., Portland, Oreg.
Elbert, G., The Pacific Tel. & Tel. Co., Portland, Oreg.
Ferguson, W. A., Pacific Power & Light Co., Portland, Oreg.
French, R. C., Puget Sound Power & Light Co., Seattle, Wash.
Hallett, L., Industrial Elec. Service Co., Rosburg, Oreg.
Hill, C. R., Univ. of Utah, Salt Lake City, Utah
Mackie, W. A., Corps of Engineers, Bonneville, Oreg.
Murakami, A., State Water Conservation Board, REA Div., Helena, Mont.
Post, J. H., General Elec. Co., Richland, Wash.
Smith, R. H., The Pacific Tel. & Tel. Co., Portland, Oreg.
Smith, W. J., Puget Sound Power & Light Co., Seattle, Wash.
Stenzel, P., Pacific Power & Light Co., Portland, Oreg.

10. Canada

Cooper, G. G., Shell Oil Co. of Canada, Ltd., Toronto, Ontario, Canada
Griffin, G. J., The Shawinigan Water & Power Co., Montreal, Quebec, Canada
Ince, G. W., Shawinigan Chemicals Ltd., Shawinigan Falls, Quebec, Canada
James, R. A. N., Elec. Power Equipment, Ltd., Vancouver, British Columbia, Canada.
Lister, R. W., Canadian Westinghouse Co., Hamilton, Ontario, Canada
McCleave, H. S., N. B. Telephone Co., Ltd., St. John, New Brunswick, Canada
Parizeau, M., Canadian General Elec. Co., Peterborough, Ontario, Canada
Phaneuf, R. E., St. Lawrence Alloys & Metals, Ltd., Beauharnois, Quebec, Canada
Racine, R. W., British Columbia Elec. Co., Vancouver, British Columbia, Canada
Ralph, J. A., Packard Elec. Co. Ltd., Montreal, Quebec, Canada
Westman, H., Shawinigan Water & Power Co., Shawinigan Falls, Quebec, Canada
Wood, A. M., Shawinigan Water & Power Co., Rapide Blanc, Quebec, Canada
Zoellner, C. M., Hydro-Elec. Power Comm., Niagara Falls, Ontario, Canada

Elsewhere

Chatterjee, B. K., Upper Ganges Valley Electricity Supply Co., Ltd., Chandausi, U.P., India
Clapham, H. E. C., Bruce Peebles & Co. Ltd., Edinburgh, Scotland
Cowan, J. M., Liverpool Corp. Elec. Supply Dept., Liverpool, England
Fingerut, B. M., Shanghai Power Co., Shanghai, China.
Gupta, A. C. D., Elect. & Mech. Works Board, Calcutta, India.
Higgins, D. F., Yenching Univ., Peiping, China.
Mikhail, S. L., Farouk I Univ., Alexandria, Egypt
Moumblow, F. J., Panama Canal, Gatun, Canal Zone
Sabbagh, V., Empresa Electrica de Guatemala, S.A. Guatemala, C.A.
Saha, N., Central Electricity Board, Glasgow, U.K.
Vallese, L., Univ. of Rome, Rome, Italy.
Webster, E. W., The English Elec. Co. Ltd., Stafford, England
Williams, H. L., A. Reyrolle & Co., Hebburn-on-Tyne, England

Total to grade of Associate

United States, Canada, Mexico, and Puerto Rico, 422

Elsewhere, 13

OF CURRENT INTEREST

ECPD Sponsors Extension of Pre-engineering Examinations

A standardized examination, similar to the 25,500 experimental tests given on a nation-wide scale last year, may become an entrance requirement of American colleges of engineering as a result of increasing acceptance of a Measurement and Guidance Project begun in 1943 by the Engineers' Council for Professional Development in co-operation with the Carnegie Foundation for the Advancement of Teaching.

Specially prepared examinations under the project include an engineering science aptitude test, suitable for purposes of guiding high school students and designed for use during the second year of high school study; and the pre-engineering inventory, which is particularly appropriate for guiding and advising prospective engineering students who have completed secondary education. There are also a series of engineering achievement tests for sophomore engineering students, and specialized examinations for graduates of the various branches of engineering.

As a part of the project during the past academic year, a total of 32,000 examinations were given throughout the United States. These included both the pre-engineering tests and the examinations for students completing their second year of college training. Doctor Kenneth W. Vaughn is the director of the project.

During 1946, 40 colleges of engineering participated in one or more phases of the work of the project. Of these, 39 colleges, including branches, gave the pre-engineering inventory to all members of the freshman class entering in the summer or fall of 1946. A number of engineering colleges which had administered the pre-engineering inventory during the past years requested that this series of examinations be available in a national testing program conducted in advance of matriculation. National examinations were conducted in March, April, and June of 1947 for 2,600 prospective college students.

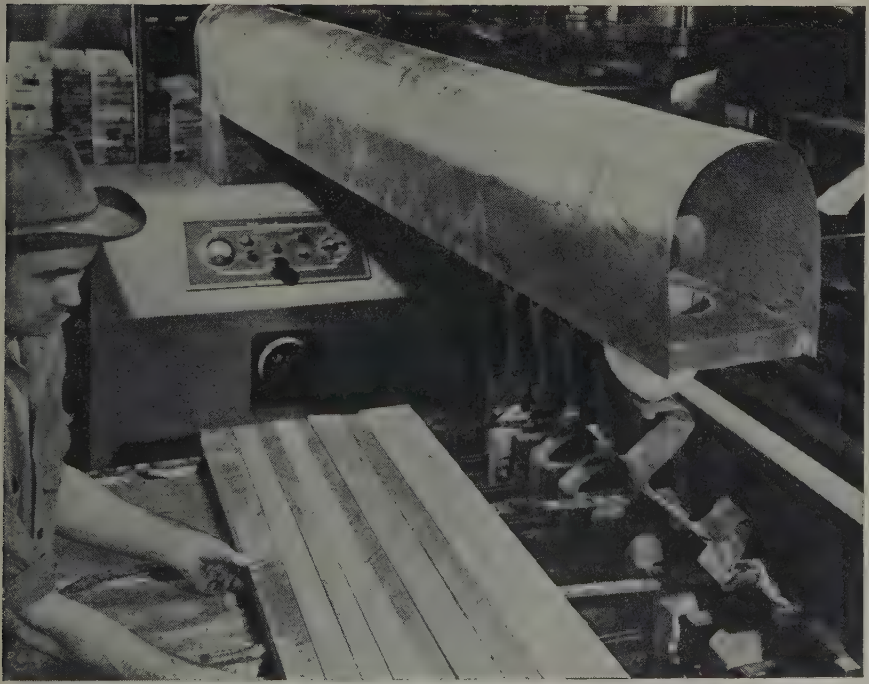
It is expected that in the future a large number of high school seniors will take this series of tests in the nation-wide examination.

The pre-engineering examination also serves as the official selection tests of the Maritime Commission in its Merchant Marine Cadet Corps training program. A total of 1,148 prospective cadets were so tested in November 1946 and March 1947. Likewise, 699 applicants for the George Westinghouse Scholarships to the Carnegie Institute of Technology were examined last March in the first nation-wide testing program.

Achievement examinations in engineering drawing, English, general chemistry, mathematics, and physics were given to more than 5,000 sophomore college students in the past year. After revision to suit the practices of various colleges, the tests will be given on a nation-wide scale in the spring of 1948. It is hoped that these tests will serve to appraise the quality of training of students who transfer from one college of engineering to another and of students who transfer to engineering colleges from a junior college or technical school.

To evaluate the worth of pre-engineering examinations, the records of students in ten institutions were compared at the end of their freshman year with the results of their pre-engineering tests. Results substantiated the value of entrance examinations in predicting the students' degree of success in engineering training.

Radio-Frequency Heating in Wood Industry



A Westinghouse Electric Corporation 10-kw 5-megacycle radio-frequency generator sets the glue in making wood panels for open-face furniture at the Fox Manufacturing Company, Rome, Ga. The fully automatic air-operated wood-gluing press used in conjunction with the radio-frequency generator was designed by the furniture company

Library Established for Rubber Industry

A nation-wide library service to promote scientific investigation in the rubber industry has been established by the Division of Rubber Chemistry of the American Chemical Society.

Started in January 1948, the new service functions at the Bierce Library of the University of Akron, where a vast literature recording developments in the rapidly expanding field of rubber technology is centralized and made available to co-operating libraries throughout the United States. A committee representing leading companies in the rubber and chemical industries is administering the new library service.

All journals of special interest to investigators in the fields of rubber, resins, and plastics are accessible in every state. Publications may be obtained through the service by applying to any co-operating

library, which in turn obtains the desired material from the University of Akron on a loan basis. The University of Akron may lend a specific journal directly, or may arrange the loan through one of the co-operating libraries. Journals may be supplied either in the original or on micro-film.

The initial list of publications has been assembled with the assistance of the Firestone Tire and Rubber Company, the General Tire and Rubber Company, The B. F. Goodrich Company, The Goodyear Tire and Rubber Company, The United States Rubber Company, and the University of Akron.

The committee has invited other libraries having sections devoted to the rubber and plastics field to co-operate, so that the collection of journals may be as extensive as possible. The Division of Rubber Chemistry is helping to fill gaps by utilizing the American Chemical Society's facilities to find missing journals, and where necessary by purchasing journals to be deposited in the Bierce Library.

Libraries interested in participating may write either to the librarian at the University of Akron or to Doctor B. S. Garvey, Jr., Sharples Chemicals, Inc., Philadelphia, Pa., chairman of the rubber division's library committee.

IBM Completes Development of Large Scale Digital Computer

The selective sequence electronic calculator recently completed by the International Business Machines Corporation, New York, N. Y., is a general purpose machine which combines electronic speed, vast memory capacity, and high flexibility. Memory capacity, an inherent limitation for large scale computer, is supplied by three methods. Eccles-Jordan circuits are used in the electronic memory unit to provide storage of 160 decimal digits. An additional 3,000 decimal digits are immediately available in the relay memory unit. The remainder of the 400,000-digit storage capacity is supplied by punched tapes.

Punched cards may be introduced to supply additional storage capacity. A modified binary code is used combining many of the advantages of the binary code with familiarity and ease of translation into familiar decimal system. In this system four channels are used for each decimal digit and the sum of the conducting channels (numbered 8,4,2, and 1) is the number being transmitted.

Programming is supplied by punched tape and a control desk. Intermediate and final results may be printed and/or recorded on punched cards. Recording speed is 24,000 digits per minute by printing and 16,000 digits per minute by punching cards.

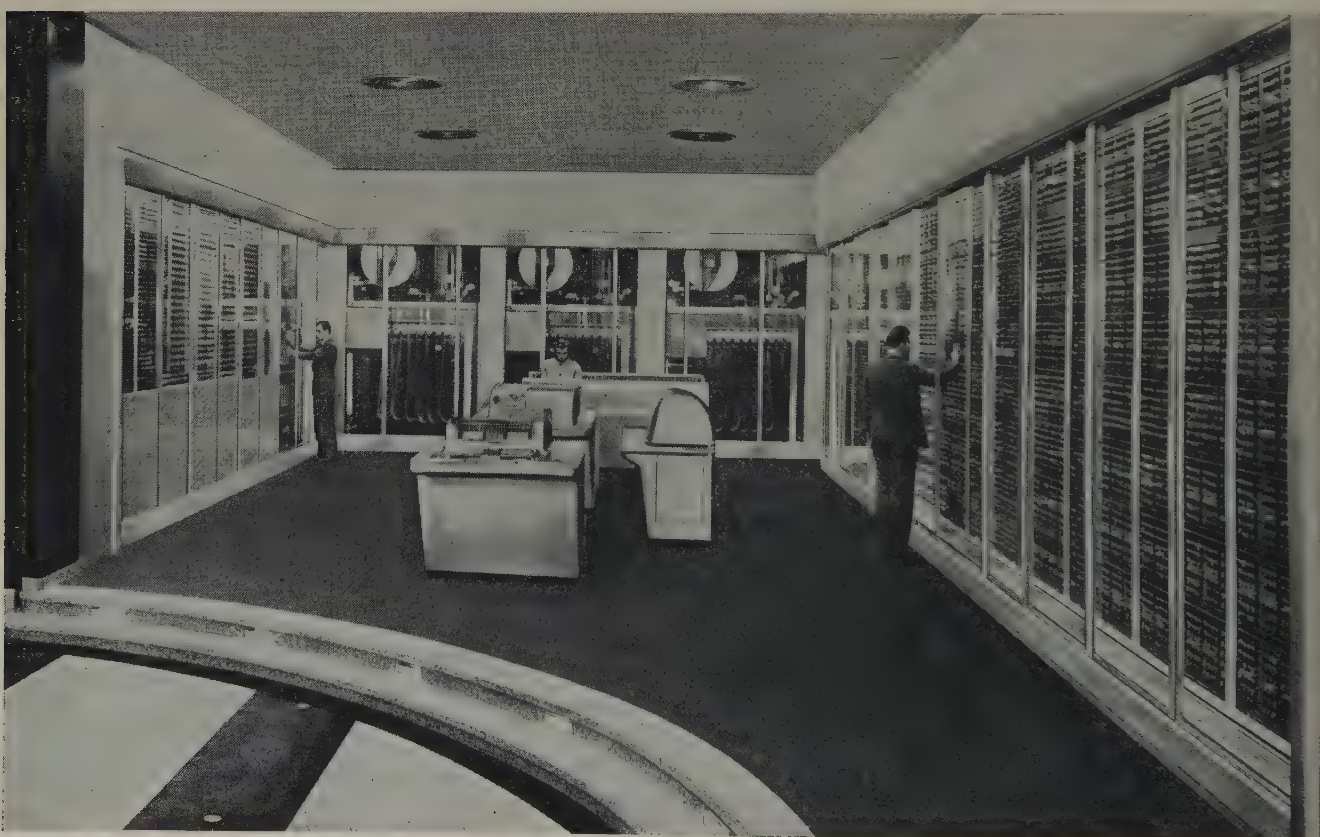
Addition and subtraction of 19-digit numbers take less than 300 microseconds, while multiplication of 14-digit numbers to give 28-digits products takes 20 milliseconds, and division consumes 50 milliseconds. Separate electronic equipment is provided for multiplication and division, addition and subtraction, and column shift. An interlock panel provides supervisory control which allows independent operation of various units but maintains interconnection.

Small neon indicating lights paralleling each component unit aid materially in indicating faults and checking operation of the machine on test runs.

Rectified alternating current is used to supply the 180 kw of electric energy demanded by the machine. Air condition-

International Business Machines' Selective Sequence Electronics Calculator which was dedicated on January 27, 1948, is located in the IBM Building, New York, N. Y.

From left to right around the wall: card reading tubes, sequence tubes, sequence relays, table look-up units, relay memory, tape memory, arithmetical units, pulse generator, sequence interlocks, and electronics memory. Equipment in the center of the room is, from front to back: card readers, card punches, printers, and console



At the console, or operation indicator and control desk, of the selective sequence electronics calculator, all stages of a computation progress may be seen by means of the indicator lights which show the units in operation, the operation being performed, and the result being achieved

ing to maintain suitable operating temperatures is capable of dissipating 200 kw of heat energy.

F. E. Hamilton directed the design, construction, and assembly of the calculator. R. R. Seeber, Jr., supervised functional and operating features. Among those assigned to the design of mechanical and electrical phases of the machine were Byron E. Phelps (A '43) and George E. Mitchell (A '44). Ralph L. Palmer (A '39) and Byron E. Phelps contributed to the development of the electronic arithmetical units.

Lighting Institute and Exhibit to be Held in Florida in Spring

Doctor Lewis J. Colman, director, Prevention of Blindness Division, Florida Council for the Blind, has announced plans for the Southeastern School Lighting Institute and School Lighting Exhibit to be held in St. Petersburg, Fla., in April 1948. The institute will last three days, April 19 to 21, while the exhibit will last four weeks. The following southeastern states have been invited to attend: Louisiana, Alabama, North Carolina, South Carolina, Georgia, Virginia, Tennessee, and Florida.

The institute and exhibit is being organized as part of a campaign for the preservation of eyesight through good lighting. The program will include speakers in the fields of lighting, education, ophthalmology, and psychology, as well as exhibits of lighting manufacturers, and is designed to show just what does constitute good lighting, good seeing conditions, and good environment in the school and classroom. A number of lighting manufacturers are expected to exhibit products.

Registration headquarters for the institute and exhibit will be at the Suwannee Hotel in St. Petersburg. Registration should be made on Sunday, April 18.

Surface Reactions Conference. The Pittsburgh International Conference on Surface Reactions will be held at the Mellon Institute for Industrial Research in Pittsburgh, Pa., June 7–11, 1948. Preliminary plans call for technical sessions mornings and evenings and visits to Pittsburgh research laboratories, which are working on surface reactions, in the afternoons. Scientists, engineers, and educators from many parts of the world have been invited to participate in the conference and many will present papers.

Electrostatic Accelerator for Brookhaven Laboratory

An electrostatic accelerator is being constructed in Schenectady by the General Electric Company for the Brookhaven National Laboratory at Upton (Long Island), N. Y.

The accelerator, one of several electronuclear machines planned for the Brookhaven atomic research center, will be installed this year. Brookhaven laboratory is being built and administered as a regional center for the Northeast by Associated Universities, Inc., under the auspices of the United States Atomic Energy Commission.

Doctor M. Stanley Livingston, head of the laboratory's accelerator project, reports that the machine, rated at 3,500,000 electron volts, first will be used for "source focusing" studies to determine, in part, the designs of other larger machines and associated equipment for the laboratory.

Ultimately the accelerator will serve as a source of high-energy particles to be directed in a beam at target elements for a variety of fundamental studies of the atomic nucleus. For example, in some experiments, the particles will be employed to study the processes of "chipping" or "splitting" atomic nuclei into fragments such as the radioactive isotopes now widely applied in research.

The electrostatic accelerator, also known as a Van de Graaff generator, in recognition of important work done in this field by Doctor R. J. Van de Graaff, of Massachusetts Institute of Technology, has an output energy considerably lower than such machines as the synchrotron, betatron, cyclotron, synchrocyclotron, and linear accelerator. However, it has the advantage of supplying high-speed atomic particles at a uniform energy.

Measurement of fundamental constants is vital in studies of the nucleus of an atom. In the case of other particle accelerators, the velocities of individual particles are not uniform, making accurate measurements difficult. In this type of accelerator, electrostatic charges are "sprayed" on two moving belts and carried to an isolated electrode in a steel tank. Particles are shot in a straight line from this sphere through a tube to a target of the element to be studied.

The belts in the machine will travel at a rate of 4,500 feet per minute. They will be 20 inches wide and will move over pulleys nine feet apart. They will be operated in a nitrogen atmosphere having a pressure of 200 pounds per square inch, and two 10-horsepower motors will be required to drive each belt.

The entire machine will be housed in a 30,000-pound steel tank, 18 feet long and eight feet in diameter. The tank's face plate, which will support much of the weight of the atom smasher, will be nine inches thick. A special building, with concrete walls two feet thick, will be built to house the machine.

Chicago Technical Conference to Meet in March in Chicago

"A Progress Report to the Nation," will be the theme of the Chicago Technical Conference, slated for March 22–24, 1948, at the Stevens Hotel, Chicago, Ill. Unique in the history of such conferences will be the emphasis on nontechnical, everyday language so that the layman may understand the discoveries, new processes, new techniques, and new materials that are molding the future of mankind.

Held in conjunction with the annual Chicago Production Show, the conference will be sponsored by the 51 scientific,

engineering, and technological societies affiliated with the Chicago Technical Societies Council. President of the council is Doctor Gustav Egloff, internationally renowned chemist, and director of research of the Universal Oil Products Company. The participating societies will show and tell in panel sessions, demonstration meetings, and exhibits, the results of wartime and peacetime research carried on in industry, universities, and laboratories.

Open to the general public, the conference sessions will cover modern advances in radio, television, refrigeration, heating and ventilating, motion pictures, food and dairy products, rubber, paper, chemistry, plastics, management engineering, metals, tools, illumination, agriculture, welding, pharmaceuticals, paints and varnishes, and many other subjects. Plans for the event include radio and television coverage in the Chicago metropolitan area.

A highlight of the conference will be the Julius Steiglitz Memorial lecture, sponsored jointly by the Chicago section, American Chemical Society, and the University of Chicago. The lecture, scheduled for Monday evening, March 22, will be delivered by one of the country's foremost scientists. The invitation to prepare this address is regarded as one of the highest honors in American science and is issued each year by the sponsoring bodies.

Prominent among the participating societies are the AIEE, the American Chemical Society, the American Institute of Mining and Metallurgical Engineers, the Institute of Radio Engineers, the Society of Plastics Engineers, the Society of Motion Picture Engineers, the Institute of Food Technologists, the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Society for Metals, the American Society of Heating and Ventilating Engineers, the American Society of Tool Engineers, the American Institute of Architects, the American Society of Lubrication Engineers, the American Pharmaceutical Association, the American Welding Society, and the Industrial Management Society.

OTHER SOCIETIES •

Eta Kappa Nu Presents 1942-47 Recognition Awards

Eta Kappa Nu, national honorary electrical engineering society, presented six recognition awards for the years 1942–47 during the AIEE winter general meeting which was held in Pittsburgh, Pa. Recognition awards were presented to six outstanding young electrical engineers, and 15 young men received honorable mentions. The presentations were made at a dinner which was held on Monday, January 26, 1948, in the Hotel William Penn.

The award, usually presented to the outstanding young electrical engineer annually, was suspended during the war years, and was brought up to date this year by the presentation of awards for the years 1942 through 1947.

W. J. Lyman (F '43), chairman of the host committee on arrangements, opened the program with a brief welcome concluding with the introduction of the toastmaster, M. S. Hibshman (F '41) Pratt Institute, Brooklyn, N. Y. C. A. Powel (F '41) chairman of the jury of awards, spoke briefly on the subject, "For Tomorrow May Be Too Late," congratulating the award recipients and pointing out that the award is quite different from most awards of this type. Most awards are presented to men well along in years, while this presentation is made, not so much for accomplishments already achieved, as for the promise for future developments that these men show. He also pointed out that the award is made not alone for technical ability, but for well-rounded interest in works of art and in civic advancement.

A list of the recipients and the year in which they won the award, together with the honorable mention winners, includes:

1942—John R. Pierce, Bell Telephone Laboratories, New York, N. Y.

Honorable Mention:

Gilbert D. McCann, Jr. (M '44) California Institute of Technology, Pasadena, Calif.

David B. Smith (A '35) Philco Corporation, Philadelphia, Pa.

1943—Nathan I. Hall, Hughes Aircraft Company, Culver City, Calif.

Honorable Mention:

Armig G. Kandoian (M '46) Federal Telecommunication Laboratories, New York, N. Y.

James W. McRae (A '37) Bell Telephone Laboratories, New York, N. Y.

1944—Richard W. Porter, General Electric Company, Schenectady, N. Y.

Honorable Mention:

William E. Ingerson, Bell Telephone Laboratories, Murray Hill, N. J.

Ernst H. Krause, Naval Research Laboratories, Washington, D. C.

Donald W. Pugsley (A '36) General Electric Company, Bridgeport, Conn.

1945—James M. Wallace (A '41) Westinghouse Electric Corporation, Pittsburgh, Pa.

Honorable Mention:

Wallace A. Depp (A '38) Bell Telephone Laboratories, New York, N. Y.

Jack A. Morton, Bell Telephone Laboratories, New York, N. Y.

Edgar A. Post, United Air Lines, Chicago, Ill.

1946—Everard M. Williams, Carnegie Institute of Technology, Pittsburgh, Pa.

Honorable Mention:

Benjamin B. Bauer, Shure Brothers, Inc., Chicago, Ill.

Albert C. Hall, Massachusetts Institute of Technology, Cambridge, Mass.

Donald L. Waidelich (M '44) University of Missouri, Columbia, Mo.

1947—Richard R. Hough (A '41) Bell Telephone Laboratories, Whippany, N. J.

Honorable Mention:

Marvin Camras (A '41) Armour Research Foundation, Chicago, Ill.

Jerome B. Wiesner, Massachusetts Institute of Technology, Cambridge, Mass.

Musical interludes in the program were presented by Winston E. Kock (recognition winner for 1938) and Larned A. Meacham (recognition winner for 1939) who rendered selections on the electronic organ and the violin, respectively. Mr. Kock, who is the inventor of the electronic organ that was played, demonstrated the versatility of the instrument during the program.

Each of the award winners received a certificate and a replica of a bronze bowl which is kept in the trophy section of AIEE headquarters in New York, N. Y. The honorable mention winners also received certificates.

Future Meetings of Other Societies

American Iron and Steel Institute. May 26–27, 1948, New York, N. Y.

American Society of Civil Engineers. Spring meeting, April 7–9, 1948, Pittsburgh, Pa.; summer convention, July 21–23, 1948, Seattle, Wash.

American Society for Engineering Education. June 14–18, 1948, Austin, Tex.

American Society for Testing Materials. Spring meeting and committee week, March 1–5, 1948, Washington, D. C.; annual meeting, June 21–25, 1948, Detroit, Mich.

American Society of Tool Engineers. Sixth annual industrial exposition, March 15–19, 1948, Cleveland, Ohio.

Canadian Institute of Radio Engineers. Convention, April 30–May 1, 1948, Toronto, Ontario, Canada.

Chicago Technical Societies Council. Chicago Technical Conference and Chicago Production Show, March 22–24, 1948, Chicago, Ill.

CIGRE (International Conference on Large Electric High-Tension Systems). Biennial meeting, June 24–July 3, 1948, Paris, France.

Edison Electric Institute. Annual engineering meetings, May 3–5, 1948, Chicago, Ill.; annual convention, June 2–4, 1948, Atlantic City, N. J.

Electric League of Western Pennsylvania. Planned lighting exhibition and conferences, March 1–4, 1948, Pittsburgh, Pa.

Institute of Radio Engineers. Annual convention and radio engineering show, March 22–25, 1948, New York, N. Y.

Midwest Power Conference. Annual meeting sponsored by Illinois Institute of Technology, April 7–9, 1948, Chicago, Ill.

National Academy of Sciences. April 26–28, 1948, Washington, D. C.

National Association of Broadcasters. 26th annual convention, week of May 17, 1948, Los Angeles, Calif.

National Association of Corrosion Engineers. Fourth annual conference and exhibition, April 5–8, 1948, St. Louis, Mo.

National District Heating Association. 39th annual meeting, May 18–21, 1948, St. Louis, Mo.

National Electrical Manufacturers Association. Winter convention, March 14–18, 1948, Chicago, Ill.

National Electrical Wholesalers Association. 39th annual convention, May 2–7, 1948, Buffalo, N. Y.

Pittsburgh International Conference on Surface Reactions. June 7–11, 1948, Pittsburgh, Pa.

Southern Machinery and Metals Exposition. Third exposition, April 5–8, 1948, Atlanta, Ga.

ACS Elects Pauling. Doctor Linus C. Pauling, chairman of the division of chemistry and chemical engineering of the California Institute of Technology and a leading theoretical chemist, has been elected president of the American

Chemical Society for 1949. Doctor Pauling took office as president-elect of the society on January 1, 1948, when Doctor Charles A. Thomas, executive vice-president and technical director of the Monsanto Chemical Company, St. Louis, Mo., became president, succeeding Doctor W. Albert Noyes, Jr., of the University of Rochester. Doctor Pauling was chosen by the society's council from four nominees receiving the largest number of votes in a national mail ballot of the society's 55,000 members.

ASCE Holds Annual Meeting in New York, January 21–24

The American Society of Civil Engineers held its 95th annual meeting, at the Hotel Commodore, New York, N. Y., January 21–24, 1948. The meeting, which was attended by approximately 2,500 civil engineers, presented a program of 14 technical sessions.

Keynote of the meeting was furnished by a report of the engineering committee authorized by the Congress to make a special 2-year study of "means for increasing the capacity and security" of the Panama Canal, and at ensuing sessions first-hand accounts of the study's technical aspects were given by the engineers who made it. This study led up to the recent recommendation to the Congress by Governor J. C. Mehaffey of the Canal Zone that a 10-year project, estimated to cost $2,483,000,000, be initiated to replace the present destructable lock-and-dam canal.

Installation of the ASCE president for 1948 took place at the annual meeting, with the new president, Richard E. Dougherty, vice-president, New York Central System, taking office to succeed E. M. Hastings of Richmond, Va. Two new vice-presidents and six new directors also were installed.

IRE Announces Plans for 1948 Convention

The Institute of Radio Engineers will hold its 1948 Annual Convention and Radio Engineering Show at the Hotel Commodore and Grand Central Palace, New York, N. Y., March 22–25. Theme of the convention and show will be "Radio-Electronic Frontiers," and both the program and exhibits are being planned to fulfill this theme.

A diversified technical program consisting of 130 papers in 26 sessions has been arranged, plus two special symposiums with invited speakers on "Nucleonics" and "Advances Significant to Electronics." The following topics will be included in the program: frequency modulation, systems, navigation aids, antennas, amplifiers, passive circuits, electronics, super-regeneration, transmission, nuclear studies, components and supersonics, television, measurements, computers, broadcasting and recording, propagation, microwaves, receivers, and active circuits.

The annual meeting of the IRE will be held on Monday, March 22; the president's luncheon on Tuesday, March 23; and the annual banquet on Wednesday, March 24. The Radio Engineering Show, featuring the products of approximately 170 exhibitors, will be held in conjunction with the convention.

ASAE Winter Meeting Held in Chicago, Ill.

The 1947 winter meeting of the American Society of Agricultural Engineers was held at the Stevens Hotel in Chicago, Ill., December 15 to 17. For the major part, the program was arranged by the society's four technical divisions: power and machinery, rural electric, farm structures, and soil and water.

Of interest to electrical engineers were the following portions of the ASAE winter meeting program: the rural electric program which included sessions on new developments in farm wiring, farm work simplification projects, uses of radiation in agriculture, and a motion picture presentation of mechanization of the poultry industry; and the farm structures and rural electric joint program which was devoted to grain and corn drying.

ASCE Confers Honorary Membership. Hardy Cross, professor of civil engineering and chairman of the department of civil engineering, Yale University, New Haven, Conn., has been made an honorary member by the American Society of Civil Engineers in recognition of his contributions to the profession. Professor Cross is prominent for his work as the originator of new methods of structural engineering analysis.

Professor Sinnott Named New President of AAAS

Edmund W. Sinnott, dean of the Sheffield Scientific School and director of the Yale University division of sciences, has been named president of the American Association for the Advancement of Science. He is a leading American geneticist.

Professor Sinnott is president of the AAAS during its centennial year and will preside over a week-long celebration to be held in Washington, D. C., from Monday, September 13 through Friday, September 17, 1948. The celebration is expected to be attended by government and science leaders from throughout the United States.

Many of the scientific societies affiliated with the American Association for the Advancement of Science will meet in Washington the week prior to the celebration. During the week of September 13–17, symposiums will be conducted which will be integrated, unified meetings in place of the section meetings held in previous years. Visits will be made also to government research laboratories and to universities in the Washington area.

The American Association for the Advancement of Science has a membership of approximately 33,000.

EDUCATION • • •

Westinghouse Fellowships Announced by Illinois

Illinois Institute of Technology now is accepting applications for the 1948 Westinghouse fellowship in power systems engineering, it has been announced by Doctor W. A. Lewis, dean of the graduate school. An award of $1,500 and free tuition for three semesters of full-time intensive training leading to a master of science degree in electrical engineering is made to the successful applicant. Candidates must have a bachelor's degree in electrical engineering from an accredited engineering college. The award will be based upon personal qualifications, interest, and scholarship.

The course of study includes both practical and theoretical training. It includes experience with the $90,000 a-c network calculator used in actual systems studies for utility and manufacturing companies. A research project in power systems engineering is determined through consultation with central station engineers of the Westinghouse Electric Corporation.

Term of the fellowship will extend three semesters from September 22, 1948, until February 1950. Further information and application blanks may be obtained from Dean Lewis, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Du Pont Company Announces 1948-49 Fellowship Plan

The Du Pont Company has announced that it is awarding 81 postgraduate and postdoctoral fellowships to 47 universities throughout the country for the 1948–49 academic year. This is an increase of six fellowships, and one university, Washington University at St. Louis, as compared with last year's awards.

Offered for the first time this year are postgraduate fellowships in electrical engineering, at the University of Illinois and Massachusetts Institute of Technology; and in metallurgy, at Lehigh University. The other three new awards are postgraduate fellowships in chemistry at Carnegie Institute of Technology, University of Delaware, and Washington University at St. Louis. All the awards made in the preceding year's program are being continued.

Each postgraduate fellowship provides

$1,200 for a single person or $1,800 for a married person, together with an award of $1,000 to the university. Each postdoctoral fellowship provides $3,000 for the recipient, with a grant of $1,500 to the university. The grants to the university are intended to finance tuition and fees, and whatever funds remain are to be used by the administering department as it sees fit. The selection of candidates for the fellowship awards and the choice of problems on which they are left to work are, as in the past, to the universities. The individual is under no obligation with respect to employment after he completes his work under the fellowship.

Founded in 1918 and continued with but one interruption ever since, the Du Pont Company fellowship plan is designed to encourage young men and women to undertake advanced study in the fields of chemistry, physics, chemical, mechanical and electrical engineering, and metallurgy. There is an ever-increasing demand in the chemical industry for students with postgraduate training in these fields.

In this year's program 45 of the company's postgraduate fellowships are in chemistry, 5 in physics, 15 in chemical engineering, 7 in mechanical engineering, 2 in electrical engineering, and 1 in metallurgy. The plan also provides for six postdoctoral fellowships in chemistry. Awards in the postdoctoral field support the development of men who would prefer to remain in academic work and who would be qualified for staff positions on graduate faculties.

HONORS

Industrial Research Medal Awarded. Games Slayter, vice-president in charge of research and development of Owens-Corning Fiberglas Corporation, has been chosen to receive the 1948 Industrial Research Institute medal presented for outstanding contribution to the field of industrial research. The Institute, composed of 93 companies representing diversified types of industry throughout the nation, cited Mr. Slayter for his leadership in the development of glass fibers and their commercial application. The medal was presented during the winter meeting of the Institute at Rye, N. Y. A previous recipient of the award was Doctor Willis R. Whitney (A '01) organizer of General Electric Research Laboratory.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

UNESCO

To the Editor:

I hope that the following letter about UNESCO from R. M. Gates (M '35) who is representative of the Engineers Joint Council on the United States National Commission for UNESCO, can be published quickly in *ELECTRICAL ENGINEERING.*

* * *

Doctor Milton S. Eisenhower, Chairman
United States National Commission for UNESCO
Department of State
Washington 25, D. C.

Dear Doctor Eisenhower:

During the recent meeting in Mexico City, Doctor Arthur H. Compton suggested I write to you about the organization we have set up in the engineering societies to co-operate with your United States National Commission for UNESCO.

The Engineers Joint Council has authorized the appointment of a committee of counsellors to advise me in my capacity as Council's representative on your Commission. The appointed counsellors are

Harold C. Dean (F '30), New York, N. Y.
Ralph L. Goetzenberger (M '20), Washington, D. C.
George C. Heikes, New York, N. Y.
Augustus B. Kinzel, New York, N. Y.
Albert B. Newman, New York, N. Y.
Brigadier General Stewart E. Reimel, New York, N. Y.
Clifford S. Strike, New York, N. Y.
Colonel Richard H. Tatlow III, New York, N. Y.
Robert M. Gates, *chairman*, New York, N. Y.

At the dinner given by Doctor Needham at the Montejo Hotel in Mexico City, I outlined certain activities in which we now are engaged and other projects, compatible with the activities of UNESCO, under consideration.

For a number of years the engineers of America have been developing an extensive international relationship. This relationship has grown because of the demand for our engineering techniques by the peoples of the world. This development of engineering service has been essential, therefore, not only to the economic development of the United States but to all countries.

The development of the applied sciences as wrought by the engineers has had a tremendous impact upon the social and political development of all nations. Realizing the importance of our work in modern civilization, we long have awaited the opportunity for further co-operation and mutual assistance that UNESCO now makes possible.

We have approximately 100,000 members in the constituent societies represented by the Engineers Joint Council. These engineering societies are selective in their membership. In order to become a member of these selective groups, one not only must be interested in the progress of his profession, but must have several members to sponsor his application. Thereafter, the prospective member is investigated for education, experience, and moral character. Hence we have in these societies a well-qualified and selected group of engineers who are the leaders in the profession. They are the executives of the large mining, construction, chemical and manufacturing companies, educators, and research men who are accustomed to putting ideas into action.

Seven thousand of these active practicing engineers, speaking the universal language of technology, and in most cases the native tongues in the 80 countries where they are working, are acquainted thoroughly with these foreign engineers and their problems. These men represent the American point of view, wherever they are. They are co-operating with engineers of other nations in the modern techniques and practices of civil, mining, mechanical, electrical, and chemical engineering. These members contribute to the proceedings in their own societies and to the technical literature which is accessible to all who are interested.

These societies have nearly 400 committees, on which almost 5,000 engineers are active. One hundred seventy-two of these committees are co-operating with allied engineering groups. There are 334 local forums, and 513 student chapters in universities. Regularly scheduled meetings both in the United States and in foreign countries keep this large group in constant touch with contemporary issues.

Since the war, more than 70,000 volumes of technical literature have been donated to libraries and colleges in the devastated areas. This activity is to be augmented. The societies have 91 centers in foreign countries for the free distribution of their published periodicals and literature. The Engineering Societies Library buys and distributes to 211 additional book centers. These are largely public or university libraries. In 1947, we had 7,000 subscriptions to our engineering periodicals from foreign countries. These were purchased by individuals, industries, and government agencies, not members of the societies.

Many of the members of our societies are also members of foreign engineering groups and many of these members regularly attend their meetings in the various foreign countries. Under the direction of these societies, we have given fully paid scholarships to foreign students to attend our universities. Individuals, as well as

committees, of the societies are participating in many activities throughout the world in technological developments of mutual interest. These apply to standards, safety, properties of gases and materials, gauges, measures, processes, alloys, and countless other subjects too extensive to outline here.

We have faith in the opportunities for UNESCO. We desire to synchronize our activities with the work of your committees. We have outlined a brief summary of our activities and facilities to give you an idea of our potential value to your Commission. May I say again that we wholeheartedly pledge our support. We will be receptive to any suggestions you have to make as to how we better can co-operate with you.

I await your pleasure should you desire to discuss this subject with us.

Respectfully yours,

(Signed) R. M. Gates

* * *

P. L. ALGER (F '30)

(Assistant to vice-president in charge of design engineering, General Electric Company, Schenectady, N. Y.)

Graduate Study

To the Editor:

Professor Sorensen's paper dealing with the graduate aspects of electrical engineering education deserves the widest possible circulation among engineering educators. An outstanding educator and engineer of broad vision is to be congratulated on his courage to speak frankly; and the Institute is to be commended on giving this article the priority publicity it deserves. Restrained and modest as the entire presentation appears at first reading, the contents point a path and carry a message of unique importance to progressive engineering educators.

For some time now, there appears to be cumulative evidence to indicate that perhaps our engineering schools have failed to meet in any great degree, a challenge of singular possibilities. Confronted by an enormous potential of engineering student applicants, there was (and still may be) a glorious opportunity to modernize outmoded engineering curricula, both at the undergraduate and graduate levels—an invitation, so to speak, to transfer the emphasis from engineering training to solid engineering education.

Admittedly, it is always a complicated, administrative (and humanitarian) matter to revise college curricula radically—if for no other more relevant reason than the effect on stabilized teaching loads of the service departments involved. However, with the present and continuing large enrollments, a marked change of emphasis on outmoded and currently irrelevant service courses would have caused only slight staff dislocations. Specifically, one thinks of numerous electrical engineering curricula, which still pay tribute to the past, by specifying disproportionately many hours in such fields as shop work, surveying, drafting, and descriptive geometry—course work which is concerned mainly with the development of special skills and techniques, rather than with critical consideration of the fundamental principles directly related to the branch of major interest. This entire question of techniques versus principles, or training versus education, in the undergraduate division, finds its counterpart at the graduate level, where advanced course work frequently involves merely a further development of specialized techniques, or even extended study of some subject at the undergraduate level. Professor Sorensen's concept of basic graduate study undoubtedly points the path for attaining that genuine professional status, so ardently sought by engineers.

It is also encouraging to note Professor Sorensen's recognition and evaluation of the factors contributing to the problem of postwar education in engineering. Among these considerations he lists a most pertinent one relating to "the men who made 20th century engineering . . . having been taught manual dexterity, the use of simple mathematics and elementary physics in solving not very complicated engineering problems." Critical reflection should reveal that a corollary to this statement is the recognition that a fair portion of present experienced teachers of electrical engineering have this identical rudimentary background, and frequently are in a position to influence curricular content and scope. An unfortunate illustration of this very situation is to be found in the excessive delay which occurred before electrical curricula were revised to give proper emphasis to the field of electronics and communications. The writer still feels that a good part of the frantic training in fundamental electronics given graduate electrical engineering personnel in the Armed Forces during the war, as in large measure due to lack of proper balance between the two major fields in undergraduate curricula. When this larger problem further is examined in the light of the dubious future of a teaching career for talented younger men, there may indeed be reason for concern.

Professor Sorensen is to be commended on his expressed recognition of the value of a sound training in physics, as well as his generous appreciation of the ability of physicists to handle many engineering problems, as indicated by recent war research activities. The need for far more emphasis on such education, particularly for graduate students, is almost axiomatic. In fact, at the doctorate level, the distinction between the two branches should, and frequently does, become redundant.

Finally Professor Sorensen hardly need be concerned about his own qualifications and background possibly being "provincial or too limited." In sharp contrast to such commendable modesty, his breadth of vision and critical perspective have formulated a program for educators, which certainly will give clearer focus and added emphasis to the needs and trends of modern professional electrical engineering education.

HENRY B. HANSTEEN

(Professor of electrical engineering, Cornell University, Ithaca, N. Y.)

Flow Meter

To the Editor:

The article by Doctor J. H. Laub in the December issue of *ELECTRICAL ENGINEERING*, "An Electric Flow Meter," presents as a new idea and a new development a measuring principle that was known 36 years ago and which has been used for about 20 years in the United States as well as in Europe.

The Laub flow meter was invented by Professor Carl Thomas, and has been described many times,[1–4] including all the essential features of the new instrument: an indicating or recording wattmeter calibrated in flow rate, and an integrating watt-hour meter, calibrated in weight.

In fact, the Thomas flow meter was the first of all electrically operated flow meters. It was developed and sold by the Cutler Hammer Manufacturing Company in Milwaukee and licensed to Cambridge Instrument Company in London, England. Some 250 Thomas flow meters were in operation in the year 1922, 25 years ago, mostly for metering gas.

The only difference between the Laub meter and the Thomas meter are

1. Measurement of a liquid flow instead of a gas flow.
2. Use of an electronic amplifier, not known in 1911.
3. The temperature compensation, which is not necessary for gas.

Production of the Thomas electrocaloric flow meter was stopped by Cutler-Hammer as well as by Cambridge about 12 years ago. Time will tell whether the rebirth of the Thomas meter will have a longer life than the first appearance 36 years ago.

I hope this will interest you and also many readers of *ELECTRICAL ENGINEERING*.

REFERENCES

1. **Carl Thomas.** *Iron Age*, New York, N. Y., volume 87, 1911, pages 676–8.

2. Catalogues 952 and 954, Cambridge Instrument Company, London, England, about 1922.

3. Thermal Volume Meter, **G. W. Penney, C. J. Fechheimer.** *AIEE Journal*, March 1928, pages 181–4.

4. Electrical Instruments in the Gas Industry (abstract), **E. X. Schmidt.** *ELECTRICAL ENGINEERING*, volume 51, March 1932, page 189.

GEORGE KEINATH (M '37)

(36 Knollwood Drive, Larchmont, N. Y.)

Phase Transformer

To the Editor:

The writer has consulted several engineers on the following problem, since there appears to be a complete absence of reference on the matter in standard publications.

The application seems to have merit, and no doubt could be appraised by one specializing in this phase of the field.

The following deals with the transformation from three phase to two phase or

vice versa, or in general from any phase to any phase. A popular textbook reference is the Scott "T" method. It seems that Mr. Scott became quite famous for his presentation of a method for transforming from a 3-phase system to a 2-phase system as a suitable standby for the Niagara Falls system. A logical and obvious approach to the problem appears as follows:

As we are dealing primarily with a rotating magnetic field the equipment involved should be of this class. This brings to mind rotating machinery rather than the conventional transformer.

The squirrel cage slip ring motor is actually a rotating transformer with an air gap. If the rotor is made so that its diameter is equal to the hole in the stator, it could be pressed in place and we would have in effect a slip ring motor without an air gap. Then of course, the rotor shaft and bearings would not be necessary.

We then would have a stationary device, in which a 3-phase stator would transform to a 2-phase rotor (originally a rotor), without the disadvantage of the air gap. Or as mentioned in the foregoing, from any phase to any phase.

In fact, this will function as a frequency converter. For example, if a 10-pole primary and a 24-pole secondary are used, it will convert from 60 cycles to 25 cycles.

Several years ago the writer had use for 2-phase power and was fortunate in locating a 2-phase slip ring motor rotor of the proper diameter to press fit into a 3-phase stator, and an oscilloscope and voltmeter showed that the proper conversion was taking place.

The writer wishes to know why this system is not used as it appears practical.

JERROLD B. WINTHER (M '47)

(Chief electrical engineer, Dynamatic Corporation Kenosha, Wis.)

NEW BOOKS • • • •

"Understanding Vectors and Phase." By John F. Rider and Seymour D. Uslan. John F. Rider, Publisher, Inc., New York, N. Y., 1947, 160 pages, paper-bound, pocket size, 99 cents. This book was written for the man lacking technical or engineering training. An understanding of vectors will make reading of articles on technical developments in radio and electronics easier for those lacking technical training, thereby assuring authors greater latitude in the preparation of technical articles.

"Theory of Servomechanisms." Edited by Hubert M. James, Nathaniel B. Nichols, and Ralph S. Phillips. Massachusetts Institute of Technology Radiation Laboratory Series, McGraw-Hill Book Company, Inc., New York, N. Y., 1947, 375 pages, cloth-bound, 9 by 6 inches, $5. This book, divided into two parts, deals first with frequency response techniques of servomechanism design. The required mathematical background is summarized and applications are described. The second section of the book presents a new design technique, which depends upon minimization of the rms error with which the mechanism produces a desired result in the presence of electrical noise and other disturbances. The relationship of the two sections of the book to each other is explored. The approach makes fundamental use of statistical methods, which are presented, together with necessary background material. The book closes with an account of the applications of these techniques to servomechanisms operating with pulsed data.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ULTRAHIGH-FREQUENCY TRANSMISSION AND RADIATION. By N. Marchand. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 322 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, cloth, $4.50. Presenting the basic principles of the radiation and transmission of electromagnetic waves, this volume is intended for both the practicing engineer and the electrical engineering student. A mathematical approach is used in the derivations, with a detailed analysis of the results to enable the reader to understand the phenomena taking place. These derivations lead to results that can be applied practically. Transmission lines, antennas, and wave guides are discussed, not only in theory, but also as items which successfully must be designed, constructed, and used.

ACID ELECTRIC FURNACE STEELMAKING PRACTICE. By C. C. Wissmann. American Society for Metals, Cleveland, Ohio, 1947. 84 pages, illustrations, diagrams, charts, tables, 7$^1/_2$ by 5 inches, paper, $1. The purpose of this booklet is to present a simple set of instructions primarily as an aid to those engaged in the operation of acid electric steel-melting furnaces. It is restricted to practical operating problems of the steelmaking process and does not cover installation, furnace types, power systems, or other related questions. Deoxidation practice and alloy additions are given particular attention.

ANALYTIC GEOMETRY. By D. S. Nathan, C. Helmer. Prentice-Hall, Inc., New York, N. Y., 1947. 402 pages, diagrams, charts, tables, 9$^1/_4$ by 6 inches, cloth, $3.50. The author's intent is not only to offer direct preparation for subsequent mathematical and engineering studies, but also to help the student develop his ability for logical thinking. To this end the book is so arranged that the various important aspects of analytic geometry, based on the early development of the concepts of the angle and the directed line segment, are carried respectively from the simple to the more complex treatments.

CALCULATING HIGH VACUUM SYSTEMS, PB-50919. By W. P. Dryer. 39 pages. NEW DEVELOPMENTS IN VACUUM ENGINEERING MDDC 52. By R. B. Jacobs, H. F. Zuhr. 38 pages. Hobart Publishing Company, Box 4127 Chevy Chase Br., Washington 15, D. C., 1946 (?), diagrams, tables, 10$^1/_2$ by 8 inches, paper, $3 each. These two publications are part of a series of special technical reports released by the Atomic Energy Commission. One of them gives methods and formulas for the calculation of the size of equipment used in creating high vacuum in vessels of industrial size. The other discusses vacuum testing methods; describes, in particular, techniques for leak detection developed with the mass spectrometer; and indicates the general utilization of those techniques.

FM RADIO HANDBOOK, 1946 EDITION. Edited by M. B. Sleeper. FM Company, Great Barrington, Mass., 1946. 174 pages, illustrations, diagrams, charts, tables, 11$^1/_2$ by 8$^3/_4$ inches, paper, $2.; cloth, $4. This first edition of the "FM Handbook" represents an attempt to compile information on a subject that still is undergoing a period of rapid growth. Only topics on which progress has begun to slow down have been discussed. Thus, such topics as transmitters and communications equipment have been omitted. The history and theory of frequency modulation, frequency modulation broadcasting and studio techniques, coaxial cables, antennas, selective calling methods, maintenance, alignment of receivers, railroad radio installations, facsimile equipment, and frequency modulation standards are among the topics included.

ORGANIZATION AND MANAGEMENT IN INDUSTRY AND BUSINESS. By W. B. Cornell. Third edition. Ronald Press Company, New York, N. Y., 1947. 819 pages, illustrations, diagrams, charts, tables, 9$^1/_4$ by 6 inches, cloth, $5. Intended for use in schools of commerce and colleges of engineering, this text presents detailed information on the varied subjects included in the field. Broad in scope, the volume covers the topics of organization and operation of a business enterprise, production control, and time study. Concrete examples are given of problems solved for well-known manufacturers. For each topic discussed, details of practical value are presented. This third edition has been revised to include up-to-date practices. New approaches to the solution of problems such as those of personnel administration have been added.

PAMPHLETS • • •

1947 ASTM Standards. The 1947 compilation of American Society for Testing Materials Standards on Electrical Insulating Materials is 580 pages, and gives in latest form the 90 specifications and tests covering a wide range of materials in this field. In addition to these standards there is an appendix discussing the significance of tests of these materials, and information on the scope and personnel of ASTM Committee D-9 which sponsors the publication. A detailed index completes the book which is available in paper cover from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa., $4.

Accident Prevention. A booklet covering one of the many phases of accident prevention in the handling and use of liquified petroleum gases has been published by the National Conservation Bureau, accident prevention division of the Association of Casualty and Surety Companies. The new booklet, "Safe Storage, Transfer and Distribution of Liquified Petroleum Gases," includes discussions on storage, liquid transfer, distribution, and cylinders. Available at ten cents each with reduced prices for quantity orders at the bureau's offices, 60 John Street, New York, N. Y.

Wage Rate Report. A breakdown of 1,100 union contracts negotiated since the passage of the Taft-Hartley Act, contains name of company, name of union, amount of wage increase negotiated, and a digest of the significant provisions of the union contract. Analysis covers contracts in 42 industries and is published by the Labor Relations Division of the National Foreman's Institute, Deep River, Conn., $2.50.